Figure 4-50
Groundwater Toluene Results 0 to 12 foot Depth Interval

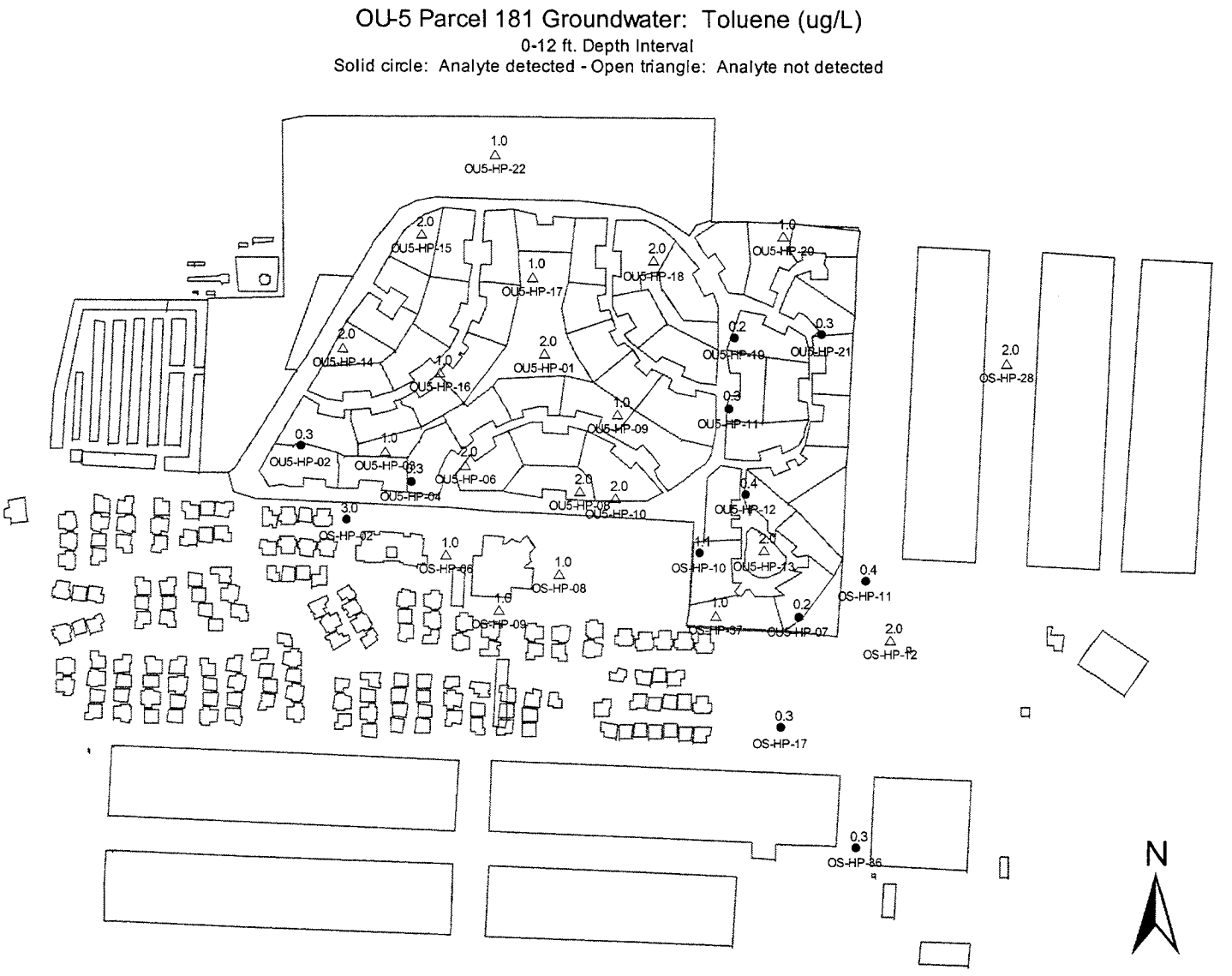


Figure 4-51
Groundwater Toluene Results 12 to 16 foot Depth Interval

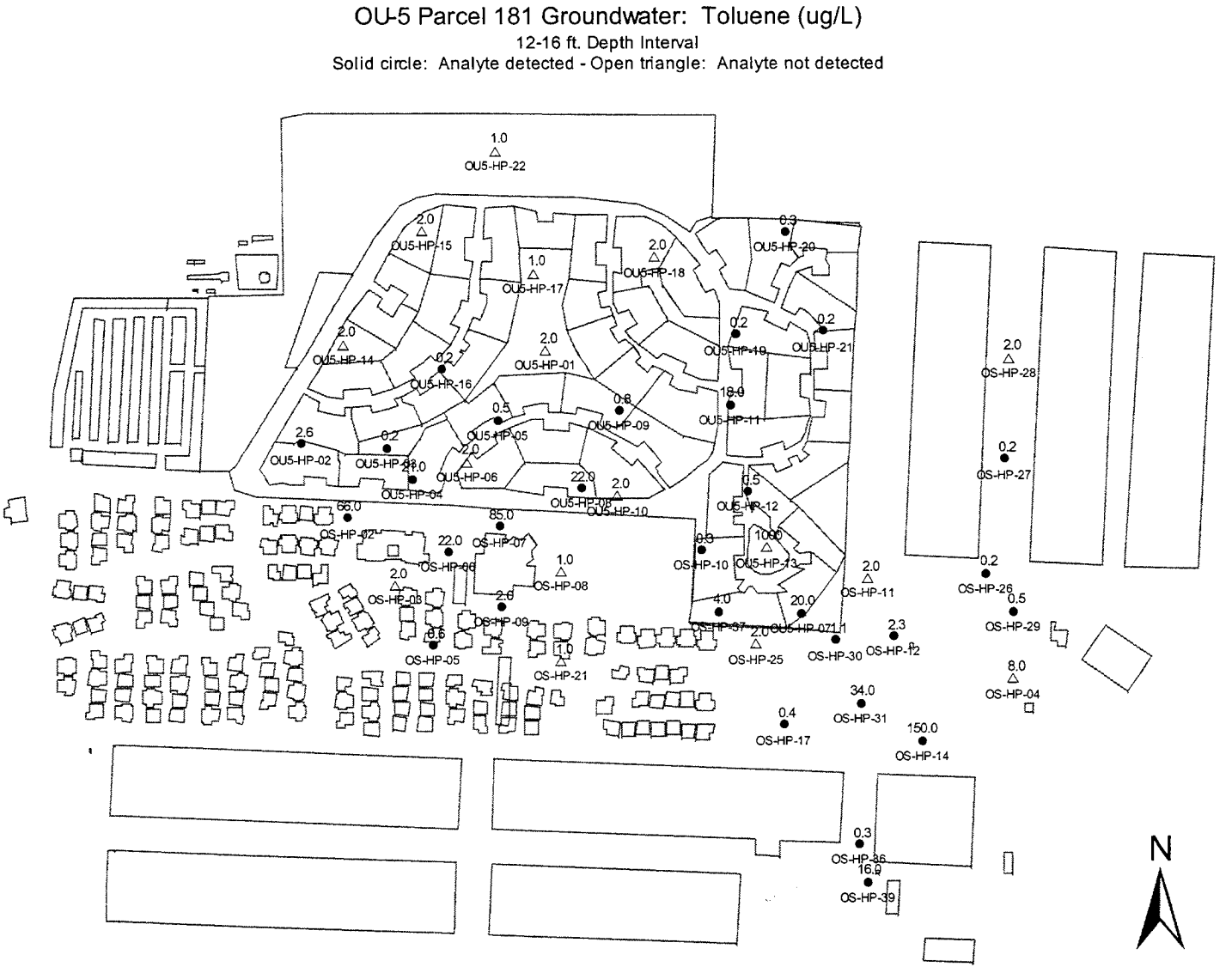


Figure 4-52
Groundwater Toluene Results 16 to 20 foot Depth Interval

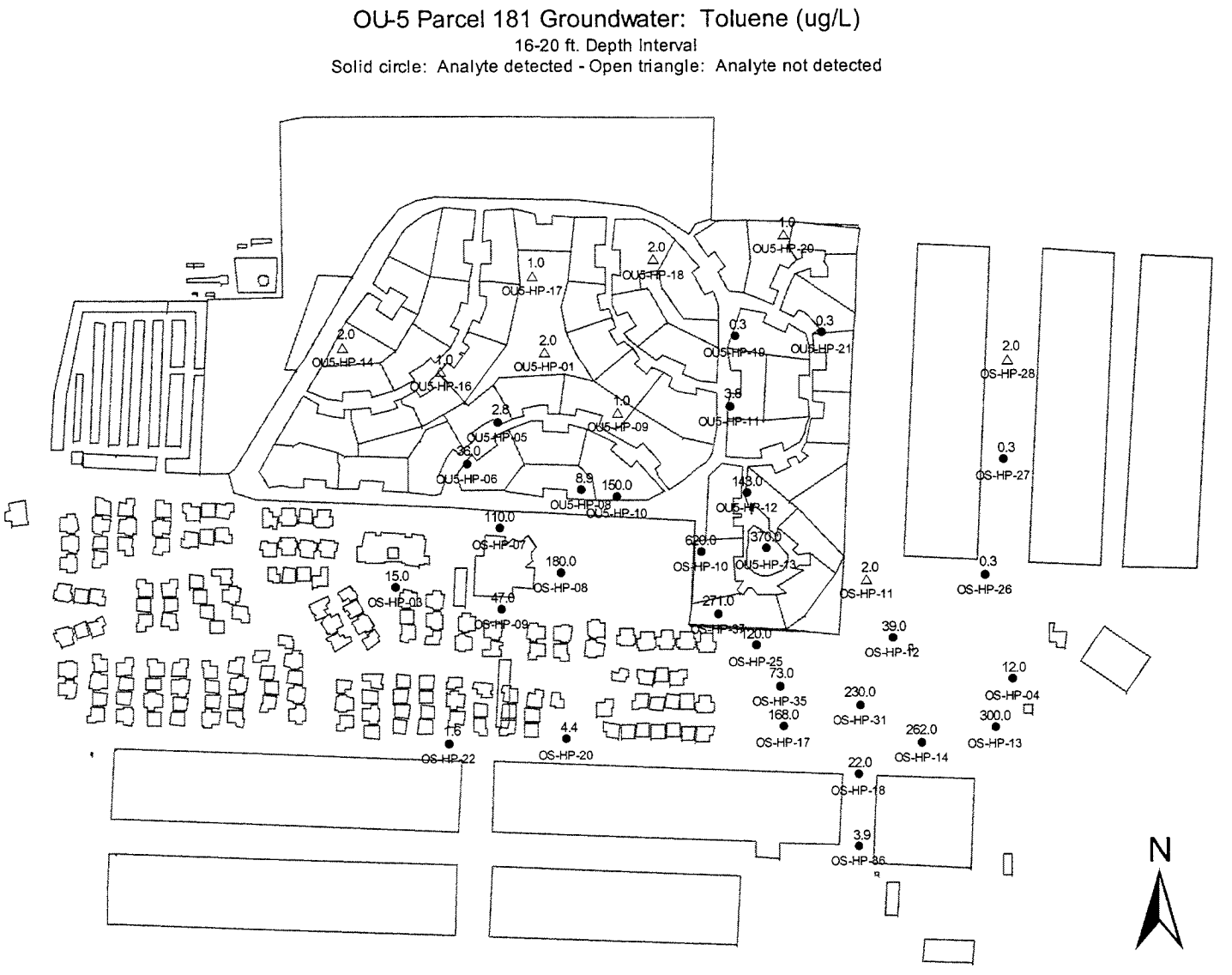


Figure 4-53
Groundwater Toluene Results 20 to 24 foot Depth Interval

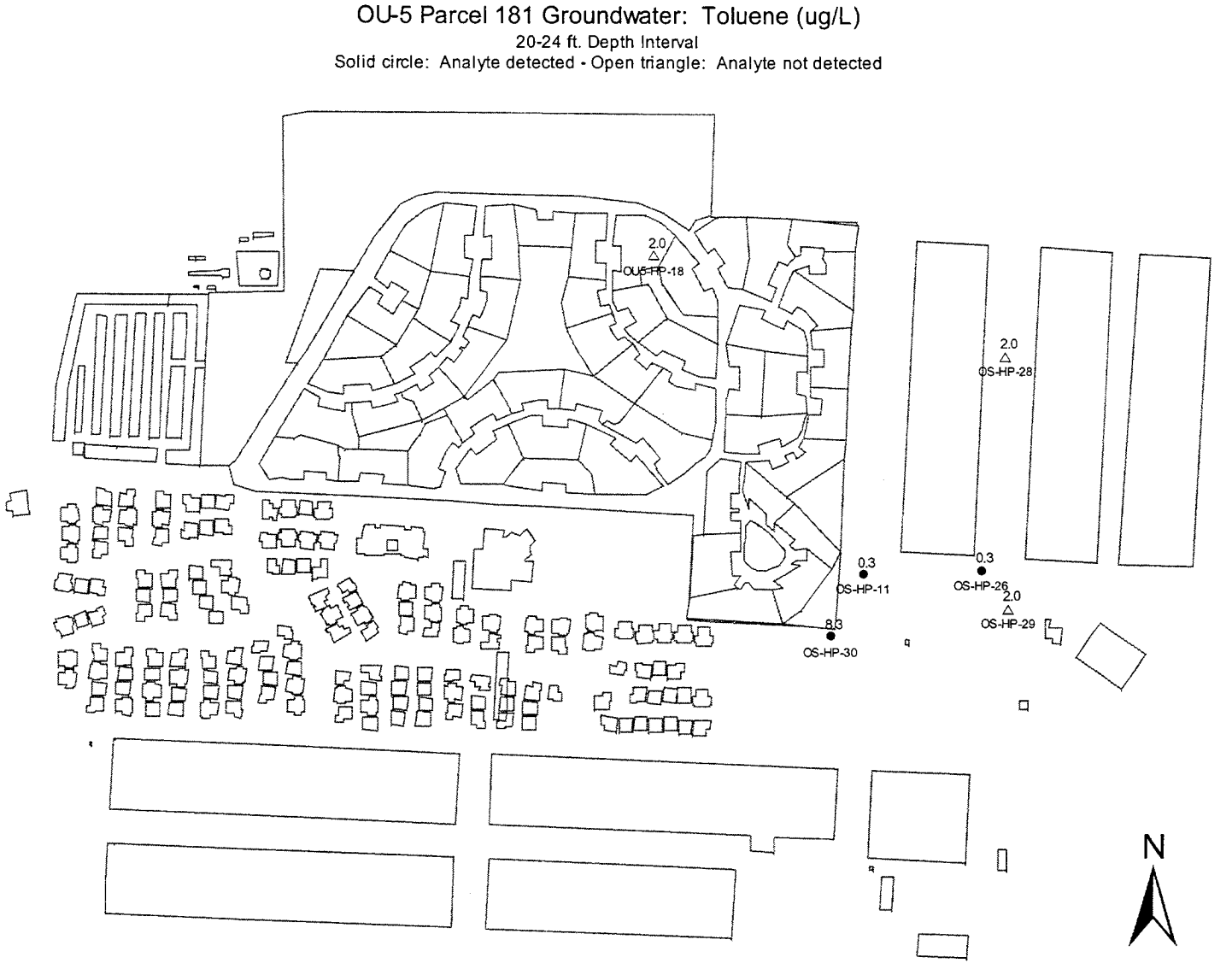


Figure 4-54
Groundwater Total Xylenes Results 0 to 12 foot Depth Interval

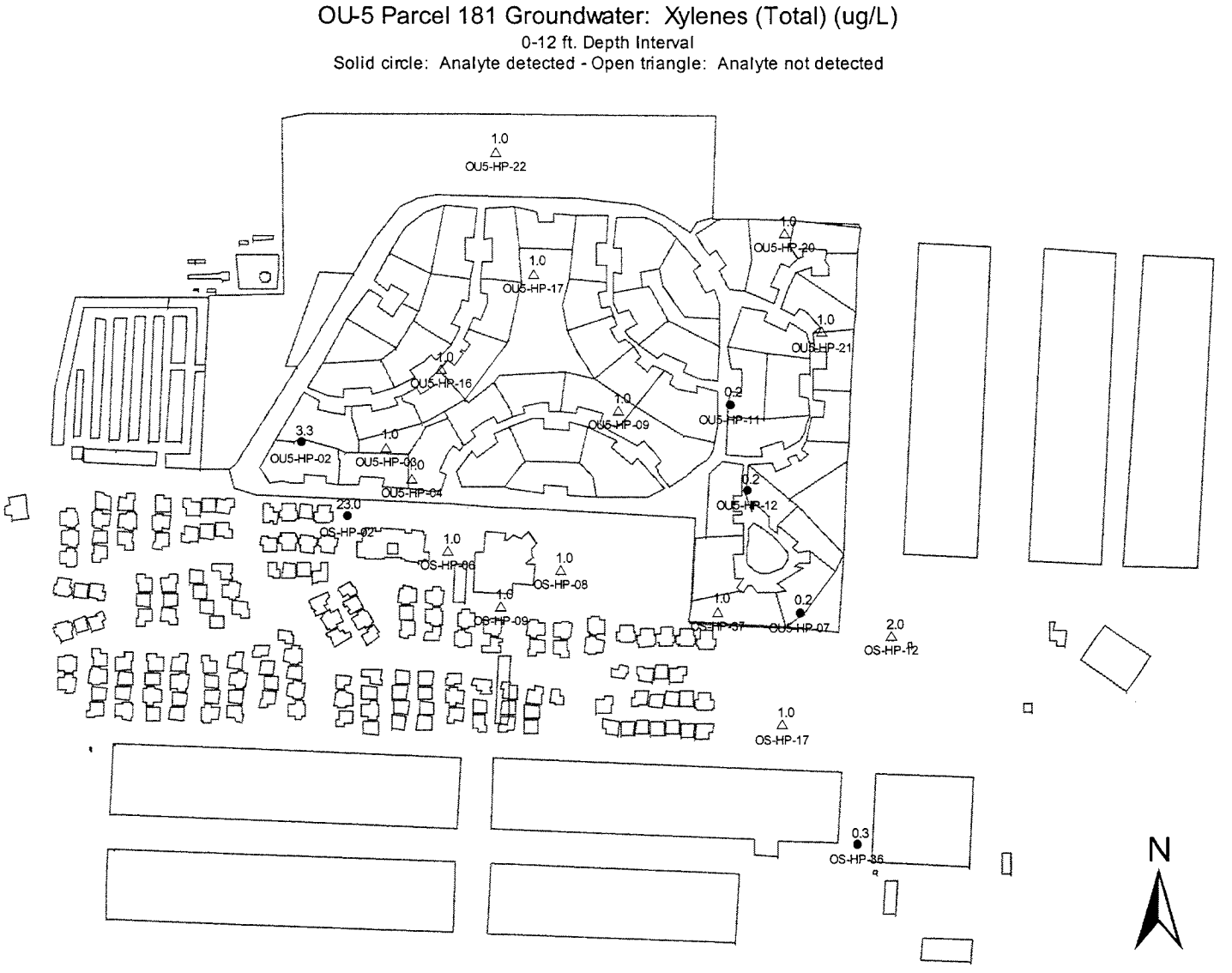


Figure 4-55
Groundwater Total Xylenes Results 12 to 16 foot Depth Interval

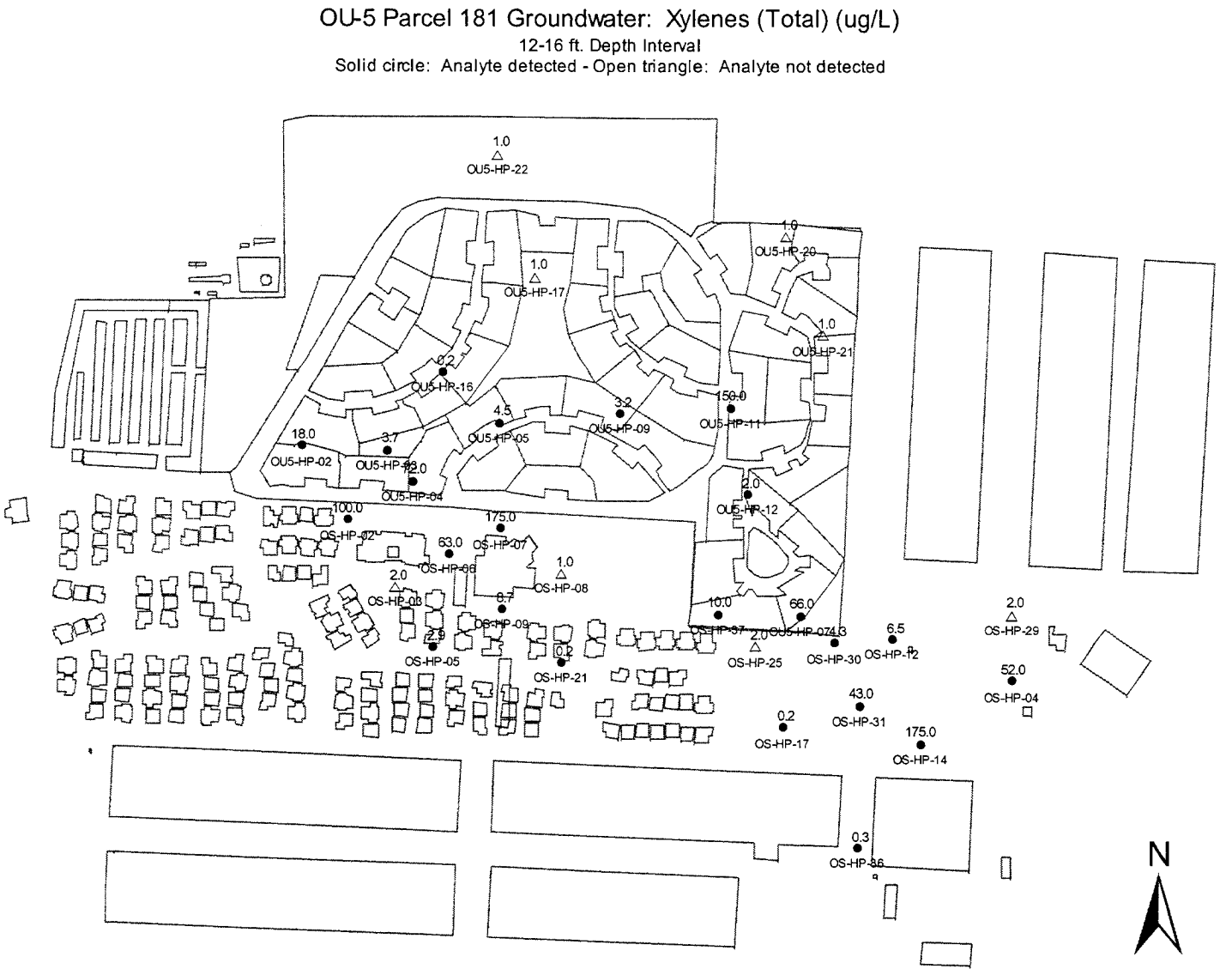


Figure 4-56
Groundwater Total Xylenes Results 16 to 20 foot Depth Interval

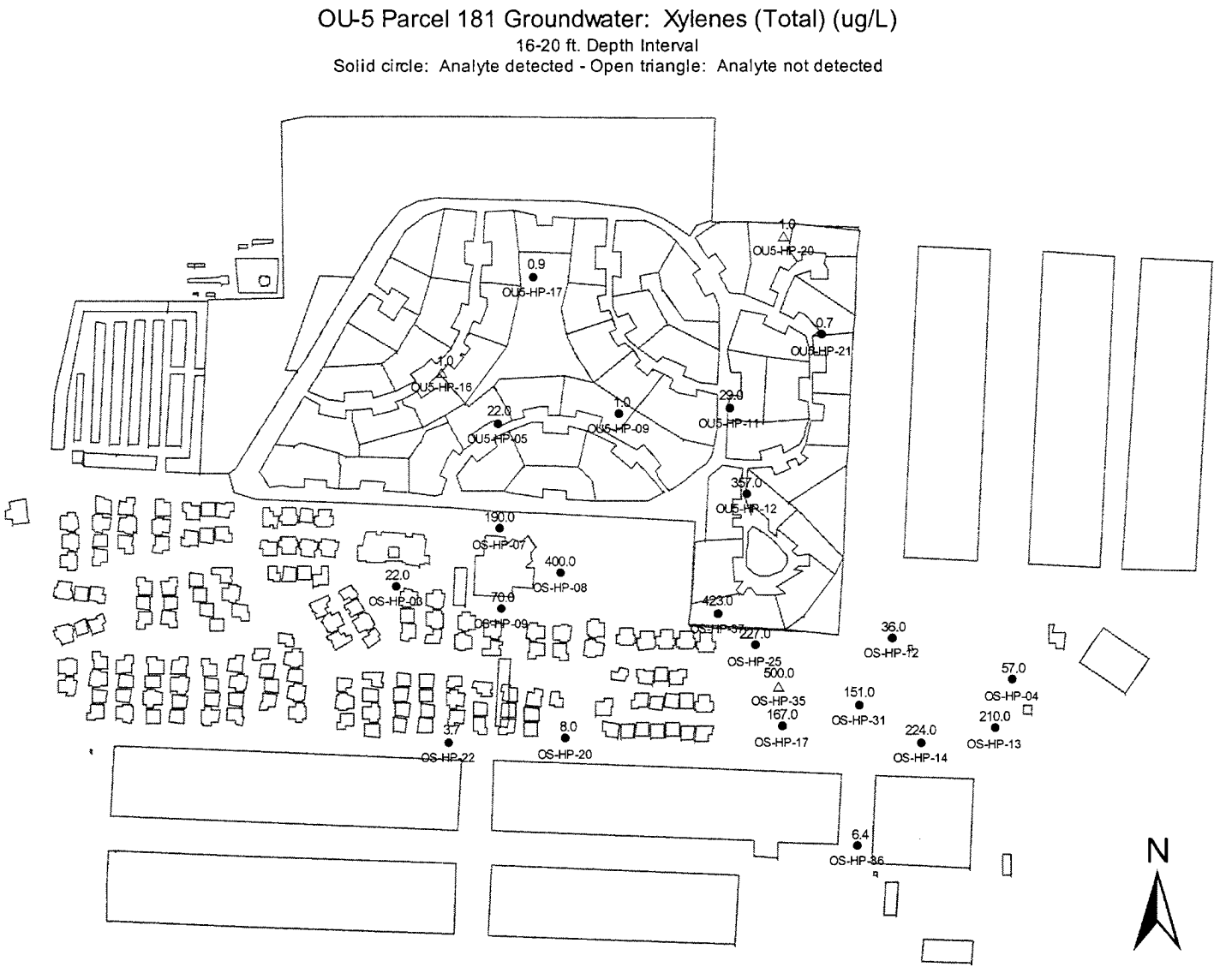


Figure 4-57
Groundwater Total Xylenes Results 20 to 24 foot Depth Interval

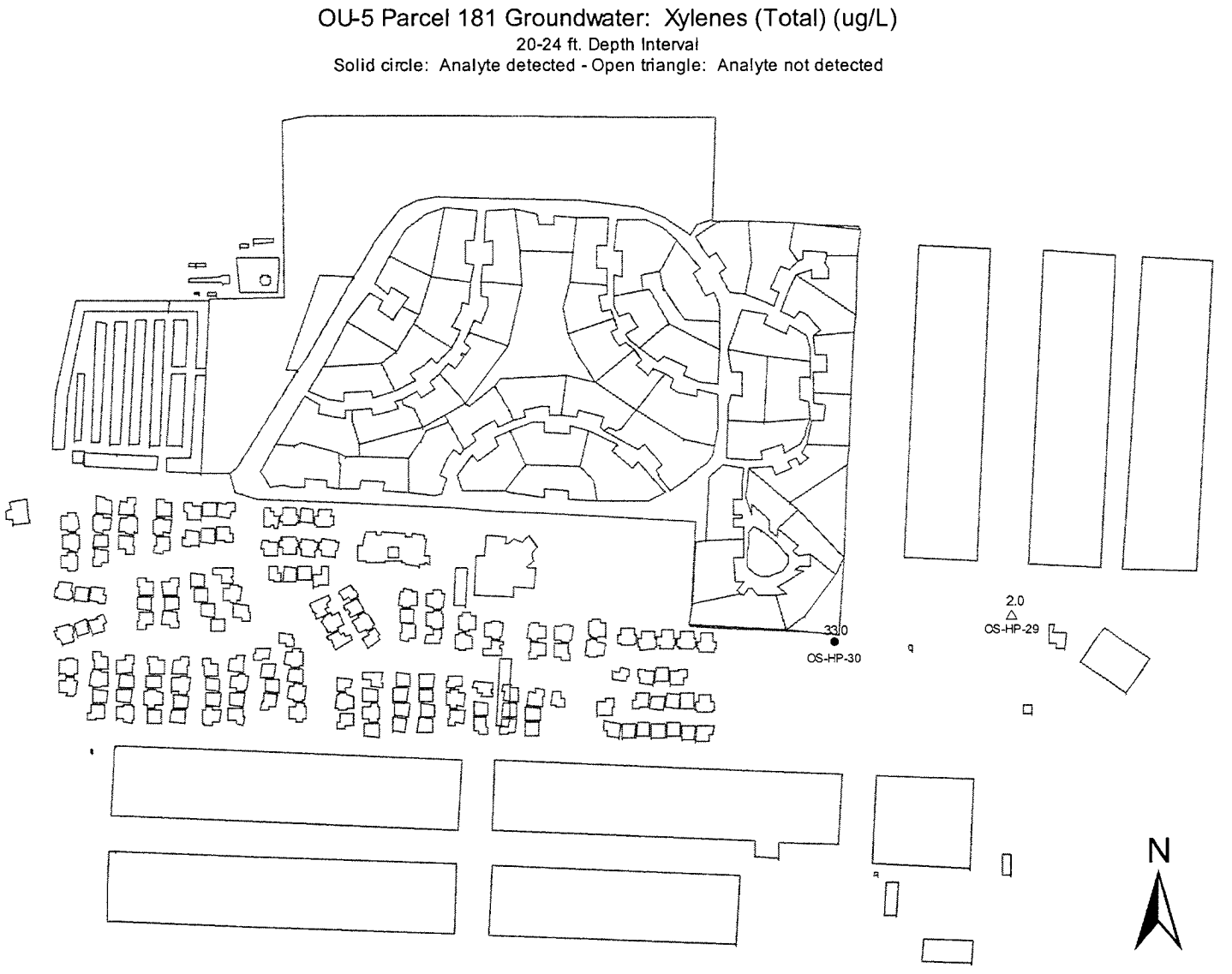


Figure 4-58
Groundwater Ethylbenzene Results 0 to 12 foot Depth Interval

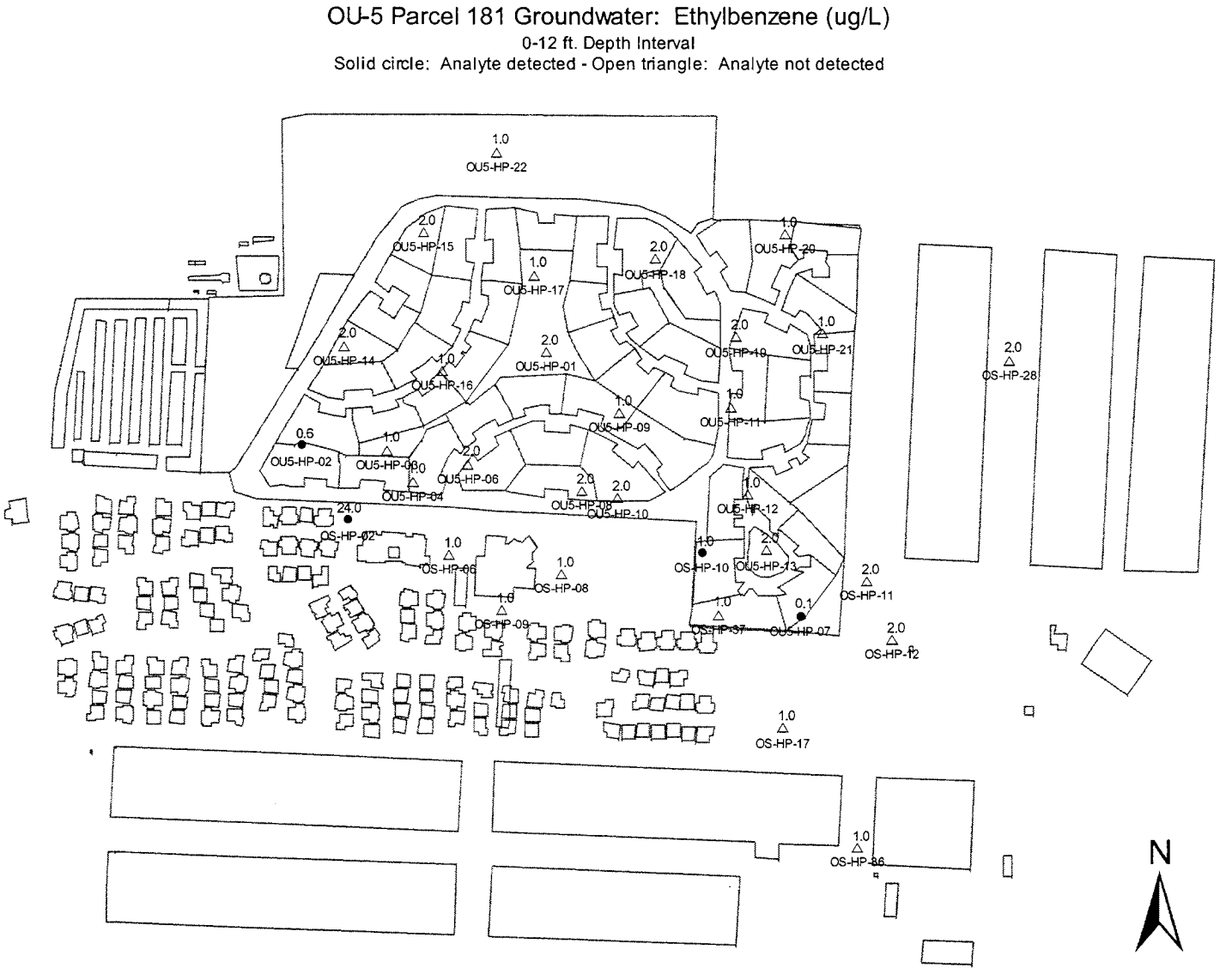


Figure 4-59
Groundwater Ethylbenzene Results 12 to 16 foot Depth Interval

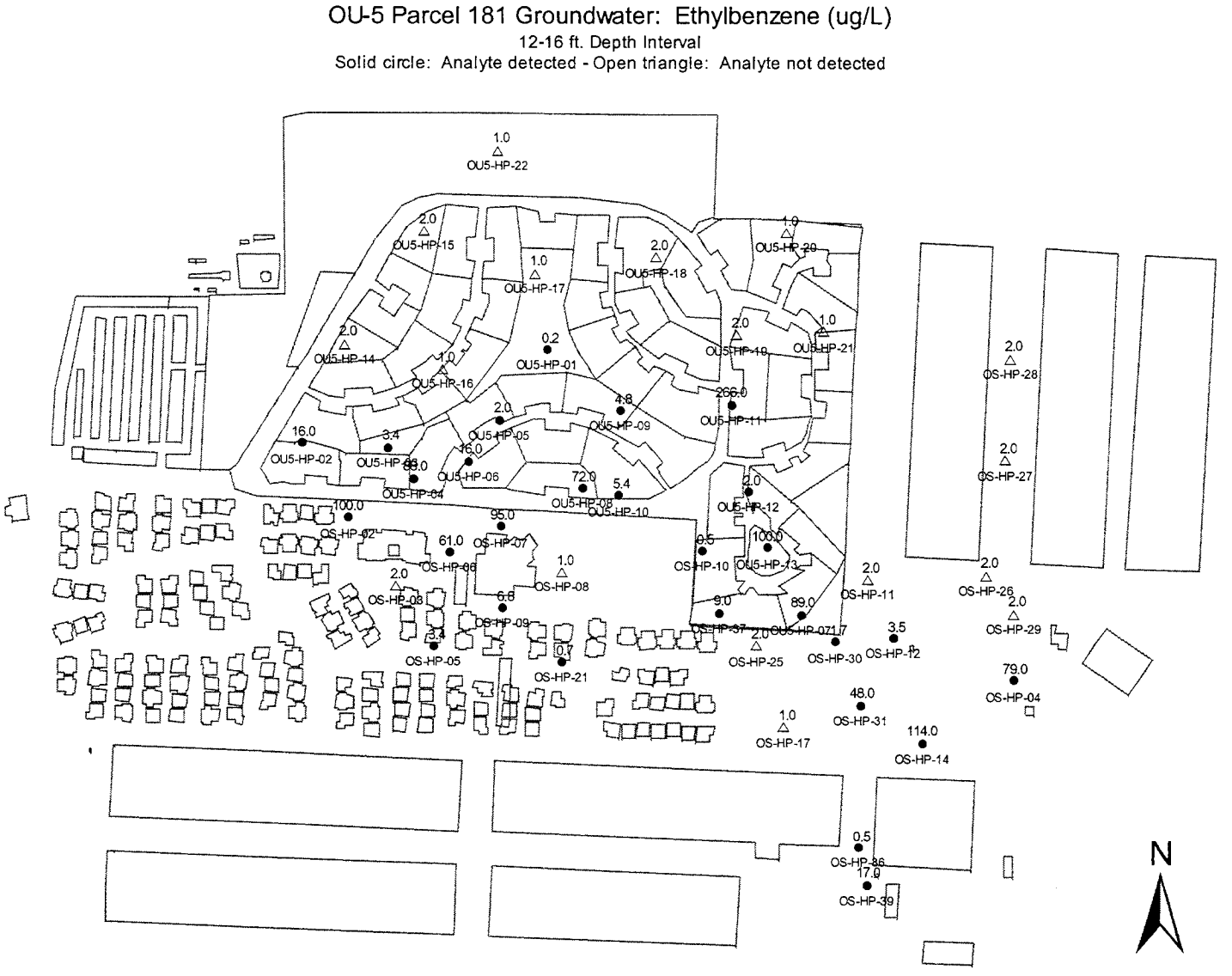


Figure 4-60
Groundwater Ethylbenzene Results 16 to 20 foot Depth Interval

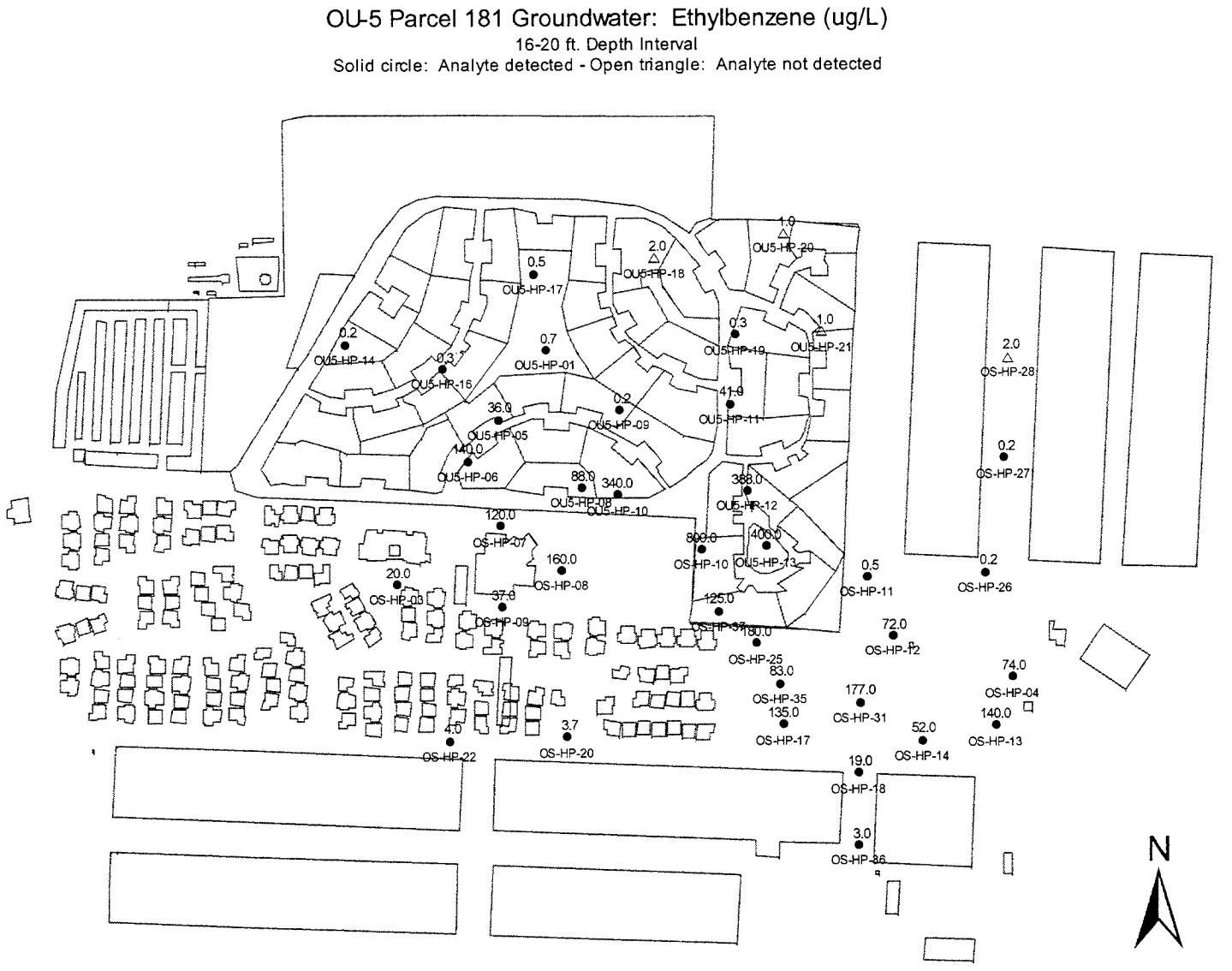


Figure 4-61
Groundwater Ethylbenzene Results 20 to 24 foot Depth Interval

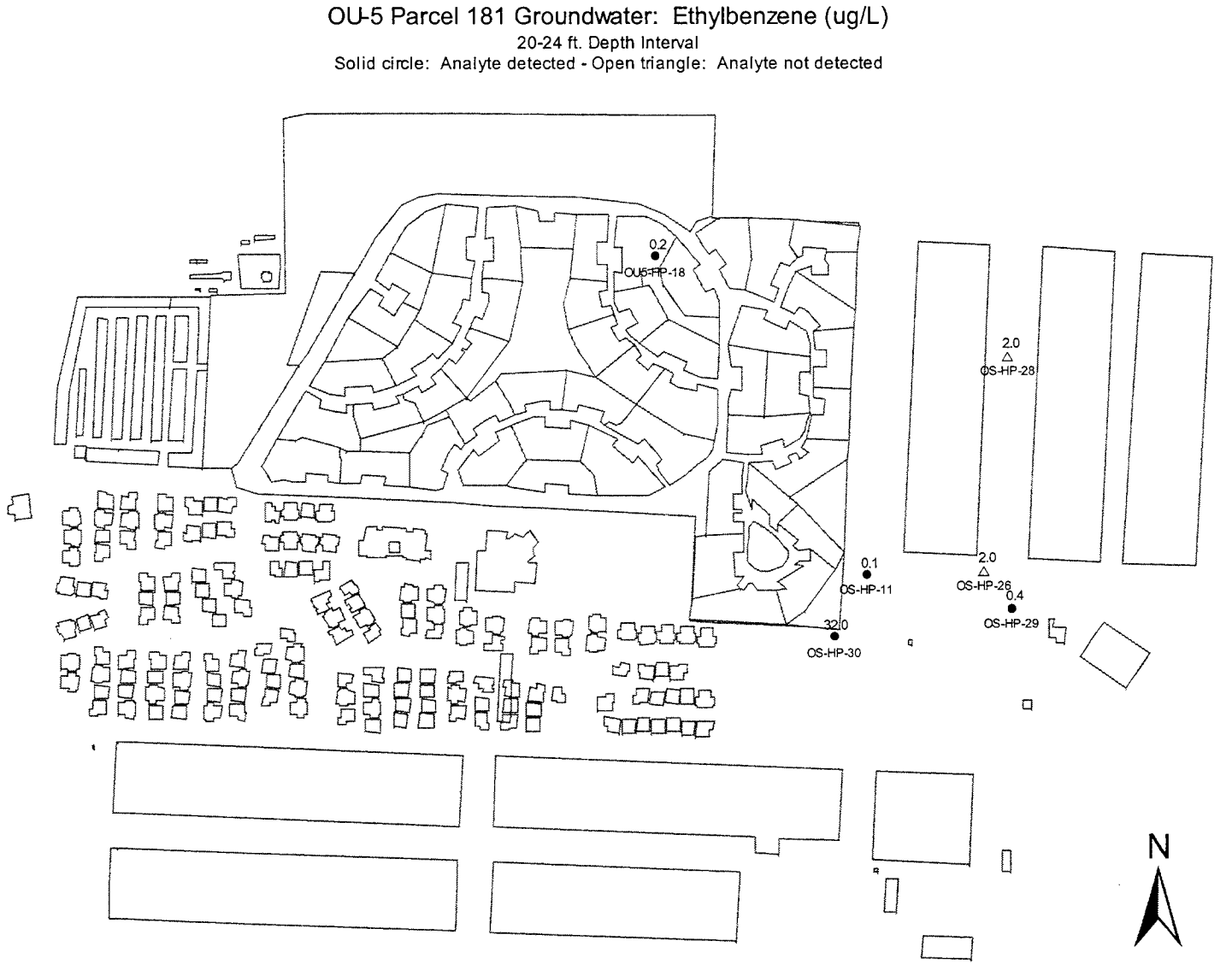


Figure 4-62
Groundwater 1,2-Dichloroethane Results 0 to 12 foot Depth Interval

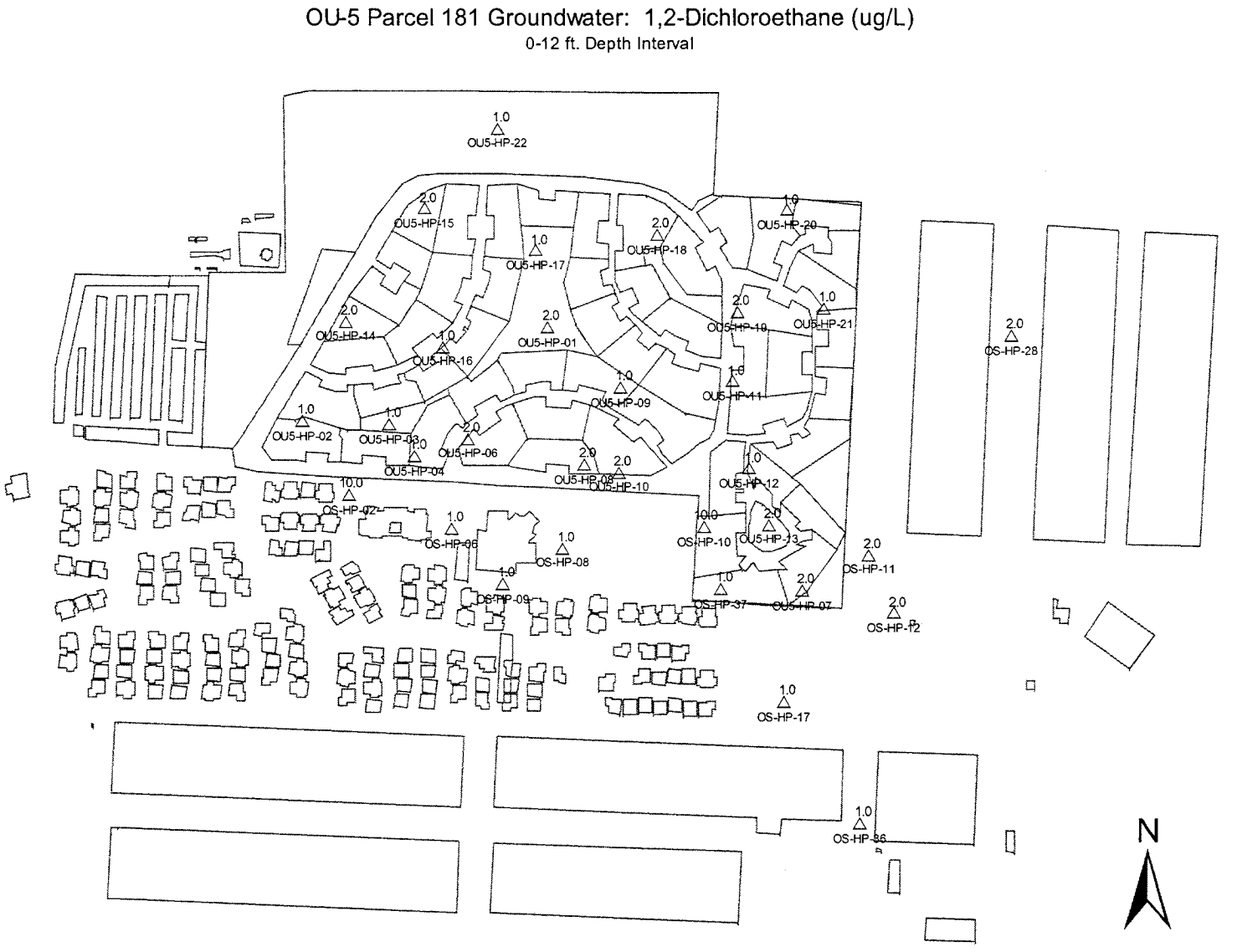


Figure 4-63
Groundwater 1,2-Dichloroethane Results 12 to 16 foot Depth Interval

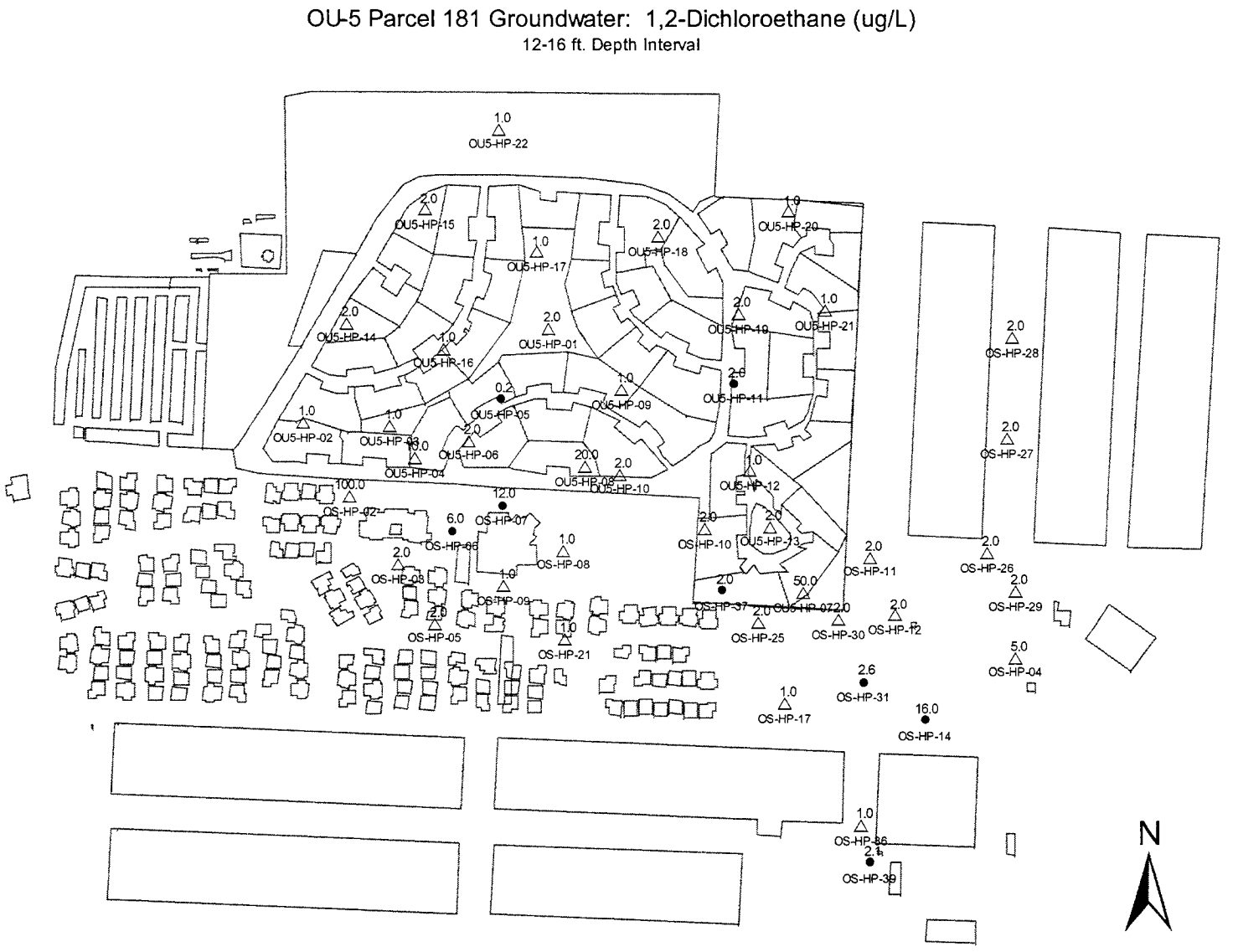


Figure 4-64
Groundwater 1,2-Dichloroethane Results 16 to 20 foot Depth Interval

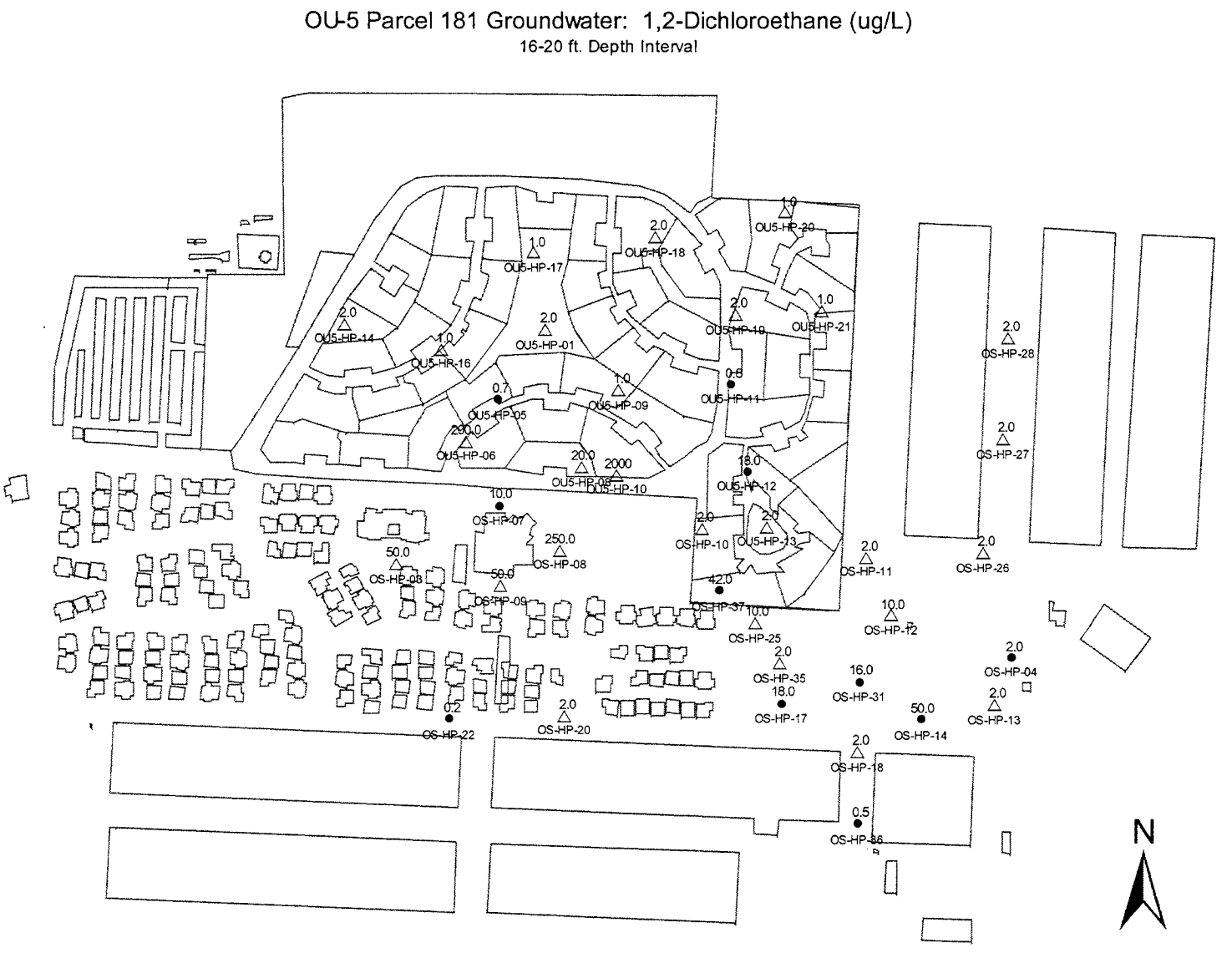
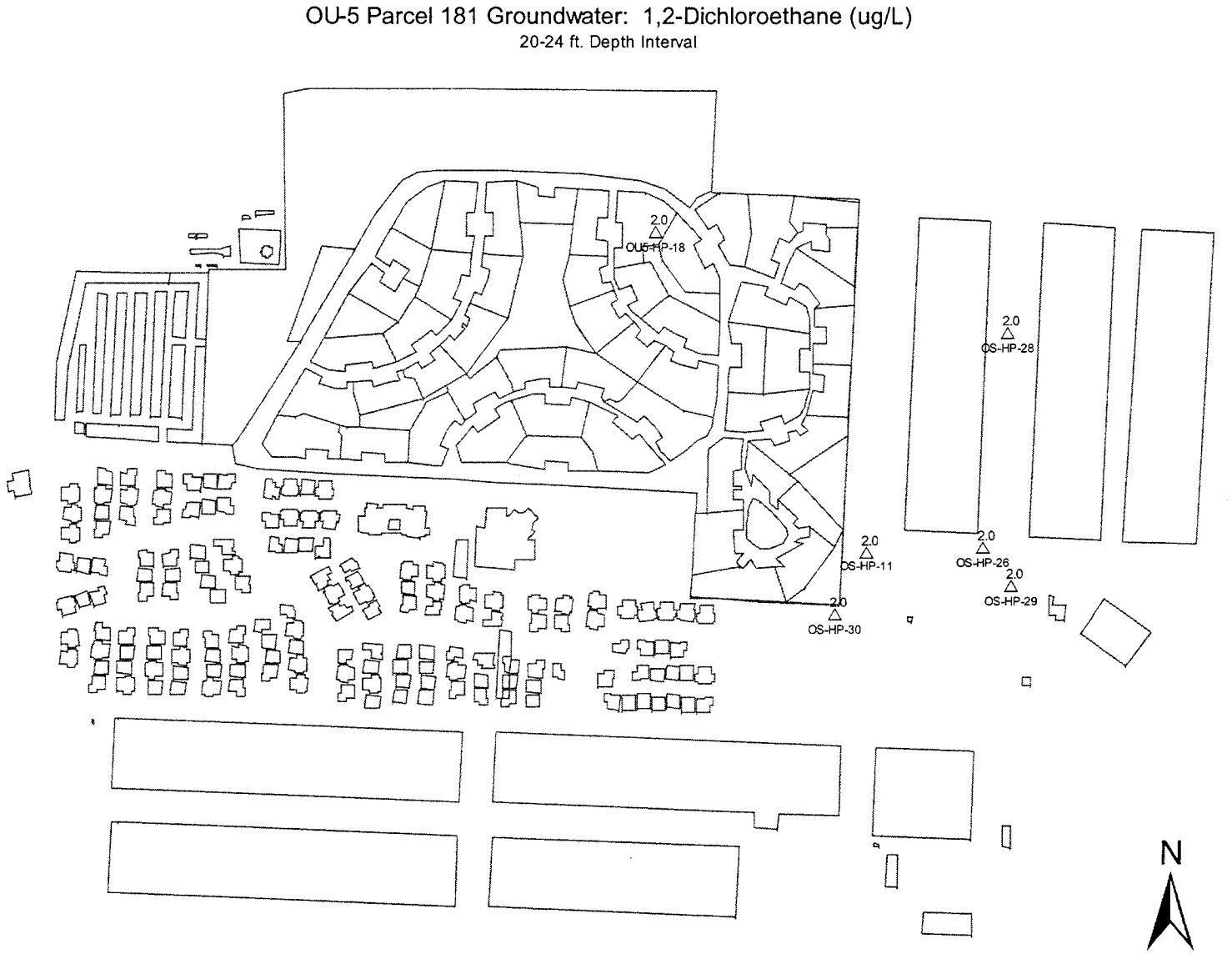


Figure 4-65
Groundwater 1,2-Dichloroethane Results 20 to 24 foot Depth Interval



from groundwater and because it had been detected in previous groundwater sampling. Other VOCs and naphthalene in groundwater are also of interest in this RI for two reasons. First, the distribution of other chemicals in groundwater is informative for evaluating the possible source(s) and migration of groundwater chemicals. Secondly, the additive effects of simultaneous exposure to benzene and other groundwater chemicals is of potential human health concern. Naphthalene, toluene, ethylbenzene, total xylenes, MTBE, and 1,2-dichloroethane were also identified as being of particular interest. The spatial distribution of these chemicals in groundwater is discussed in the following paragraphs.

Figures 4-44 through 4-46 show naphthalene detections for the shallow (0 to 12 feet bgs), intermediate (12 to 16 feet bgs), and above and top of the marsh crust (16 to 20 feet bgs) sampling intervals. Reported naphthalene concentrations for samples collected from the shallow sampling interval were generally low, with a maximum reported concentration of 270 µg/L at OS-HP2 (see Figure 4-44). There were more naphthalene than benzene detections in this sampling interval and the areal distribution of detections was more widespread as well.

Naphthalene results from the intermediate sampling interval are shown on Figure 4-45. The maximum detection was 5,660 µg/L at OU5-HP11. The naphthalene isoconcentration contours show a roughly similar pattern to that of benzene in this interval (see Figure 4-46). The high concentration areas are also roughly the same as for benzene.

The maximum reported concentration of naphthalene for samples collected from the sampling interval above and at the top of the marsh crust (16 to 20 feet bgs) was 13,000 µg/L at OU5-HP13 (the maximum qualified result was 19,000J µg/L at OS-HP13). Figure 4-46 shows the distribution of naphthalene in groundwater for the sampling interval above and at the top of the marsh crust. The overall distribution pattern of naphthalene within the sampling interval was larger than that for the intermediate sampling interval. The areas of high concentrations were also roughly similar to those for benzene in this interval (see Figure 4-42). Only four samples were recovered from the sampling interval at the upper portion of the BSU and the detections were 29 µg/L (OU5-HP18), 0.44J µg/L (OS-HP11), 0.69J µg/L (OS-HP26), and 3.9 µg/L (OS-HP28). No map was generated for this interval.

The relative concentrations of benzene and naphthalene in Hydropunch® samples and monitoring well samples differed between these two chemicals. For example, the reported naphthalene concentration for Well P181-MW45, which is located within the high concentration area of the plume, was non-detect at a reported concentration of 5 (U-qualified) µg/L (see Figure 4-45). However, benzene detections in Well P181-MW45 (149 µg/L) had a reported

concentration similar to that from the nearby direct-push sample (see Figure 4-41). The reason for this difference may be related to higher concentrations of suspended solids in the direct-push samples. Table 4-7, "Summary Statistics of the Polynuclear Aromatic Hydrocarbon Monitoring Well Data" and Table 4-8, "Summary Statistics of the Volatile Organic Compounds Monitoring Well Data" list the summary statistics for the monitoring well PAH and VOC results.

The groundwater concentrations of toluene, total xylenes, and ethylbenzene are plotted in Figures 4-50 through 4-53, 4-54 through 4-57, and 4-58 through 4-61, respectively. The spatial distributions of these three chemicals are generally similar to the distribution of benzene in groundwater, discussed above. The concentrations are usually highest in the depth interval above and at the top of the marsh crust (16 to 20 feet bgs) in the southeast portion of OU-5. The plume extends to the south and east away for OU-5 (into Parcel 176) with lower groundwater concentrations beneath Parcel 176.

The groundwater concentrations of 1,2-dichloroethane and MTBE are plotted in Figures 4-62 through 4-65 and 4-47 through 4-49, respectively. These chemicals may be associated with petroleum fuels of more recent production. Therefore, comparison of the distribution of groundwater concentrations of these chemicals with those of benzene, toluene, ethylbenzene, and xylenes (BTEX) and naphthalene is potentially valuable for evaluating the source of release(s) to groundwater. In the case of 1,2-dichloroethane there were limited detections. Most of the detected concentrations of 1,2-dichloroethane occurred in the area in the southeast corner of Parcel 181 and around Parcel 176. The 1,2-dichloroethane plume roughly coincides with the benzene and naphthalene plumes. The detections of MTBE are quite low and discernable patterns are not readily evident.

Direct-push groundwater samples were also analyzed for PAHs besides naphthalene. Table 4-6 lists the number of samples, frequency of detection, and concentration range for detects and non-detects for PAHs from direct-push groundwater samples. All values discussed below are expressed as BaP-equivalent concentrations. No distribution figures are provided due to the low concentrations detected. The maximum reported concentration in the shallow sampling interval was 18 µg/L in OU5-HP18. The intermediate sampling interval had a maximum reported concentration of 35 µg/L at OU5-HP10 (maximum qualified detection was 41J at OU5-HP08). The maximum reported concentration for above and at the top of the marsh crust sampling interval was 71 µg/L at OS-HP20. Of the four samples collected from the upper portion of the BSU, the maximum reported concentration was 0.58 µg/L at OS-HP26. The maximum detected BaP-equivalent concentration from monitoring well samples was 1.9 µg/L from

Table 4-7
Summary Statistics of the Polynuclear Aromatic Hydrocarbon Monitoring Well Data

Analyte	Number of Samples			Percent Detects	Reporting Limits for Nondetects (µg/L)		Overall Mean (µg/L)	Detected Concentrations (µg/L)		
	Total	Nondetects	Detects		Minimum	Maximum		Minimum	Mean	Maximum
BaP EQUIVALENT	9	6	3	33.3	0.38	15	1.5	0.39	0.8	1.9
BENZ(A)ANTHRACENE	9	7	2	22.2	0.2	8	0.7	0.2	0.3	0.4
BENZO(A)PYRENE	9	9	0	0	0.2	8	0.7			
BENZO(B)FLUORANTHENE	9	9	0	0	0.2	8	0.7			
BENZO(G,H,I)PERYLENE	9	9	0	0	0.2	8	0.7			
BENZO(K)FLUORANTHENE	9	9	0	0	0.2	8	0.7			
CHRYSENE	9	6	3	33.3	0.2	8	3.1	0.3	7.46	21.1
DIBENZ(A,H)ANTHRACENE	9	9	0	0	0.5	20	1.8			
FLUORANTHENE	9	1	8	88.9	0.2	0.2	3.6	0.09	4.05	7.34
INDENO(1,2,3-CD)PYRENE	9	9	0	0	0.2	8	0.7			
PYRENE	9	2	7	77.8	0.2	0.2	4.4	1.4	5.67	10.6
ACENAPHTHENE	9	4	5	55.6	5	200	25	3	17.6	66
ACENAPHTHYLENE	9	5	4	44.4	2	10	35.1	3	76.7	190
ANTHRACENE	9	2	7	77.8	0.2	1	2.2	0.06	2.7	8
FLUORENE	9	3	6	66.7	1	1	6.0	0.2	8.8	36
NAPHTHALENE	9	2	7	77.8	5	5	473	10	608	2200
PHENANTHRENE	9	1	8	88.9	1	1	17	0.2	19.7	80

µg/L denotes microgram(s) per liter

Table 4-8 (Page 1 of 4)
Summary Statistics of the Volatile Organic Compounds Monitoring Well Data

Analyte	Number of Samples			Percent Detects	Reporting Limits for Nondetects (µg/L)		Overall Mean (µg/L)	Detected Concentrations (µg/L)		
	Total	Nondetects	Detects		Minimum	Maximum		Minimum	Mean	Maximum
MTBE	9	5	4	44.4	5	130	14	1	6.5	19
1,1,1,2-TETRACHLOROETHANE	9	9	0	0	1	25	2.5			
1,1,1-TRICHLOROETHANE	9	9	0	0	1	25	2.5			
1,1,2,2-TETRACHLOROETHANE	9	9	0	0	1	25	2.5			
1,1,2-TRICHLOROETHANE	9	9	0	0	1	25	2.5			
1,1-DICHLOROETHANE	9	9	0	0	1	25	2.5			
1,1-DICHLOROETHENE	9	9	0	0	1	25	2.5			
1,1-DICHLOROPROPENE	9	9	0	0	1	25	2.5			
1,2,3-TRICHLOROBENZENE	9	9	0	0	1	25	2.5			
1,2,3-TRICHLOROPROPANE	9	9	0	0	1	25	2.5			
1,2,4-TRICHLOROBENZENE	9	9	0	0	1	25	2.5			
1,2,4-TRIMETHYLBENZENE	9	4	5	55.6	1	5	2.4	0.4	3.2	11
1,2-DIBROMO-3-CHLOROPROPANE	9	9	0	0	1	25	2.5			
1,2-DIBROMOETHANE	9	9	0	0	1	25	2.5			
1,2-DICHLOROBENZENE	9	9	0	0	1	25	2.5			
1,2-DICHLOROETHANE	9	4	5	55.6	1	5	8.0	0.9	13.5	39
1,2-DICHLOROPROPANE	9	9	0	0	1	25	2.5			
1,3,5-TRIMETHYLBENZENE	9	4	5	55.6	1	25	3.6	0.6	3.2	8
1,3-DICHLOROBENZENE	9	9	0	0	1	25	2.5			

Table 4-8 (Page 2 of 4)
Summary Statistics of the Volatile Organic Compounds Monitoring Well Data

Analyte	Number of Samples			Percent Detects	Reporting Limits for Nondetects (µg/L)		Overall Mean (µg/L)	Detected Concentrations (µg/L)		
	Total	Nondetects	Detects		Minimum	Maximum		Minimum	Mean	Maximum
1,3-DICHLOROPROPANE	9	9	0	0	1	25	2.5			
1,4-DICHLOROBENZENE	9	9	0	0	1	25	2.5			
2,2-DICHLOROPROPANE	9	9	0	0	1	25	2.5			
2-CHLOROTOLUENE	9	9	0	0	1	25	2.5			
4-CHLOROTOLUENE	9	9	0	0	1	25	2.5			
BENZENE	9	1	8	88.9	1	1	286	9.6	322	1620
BROMOBENZENE	9	9	0	0	1	25	2.5			
BROMOCHLOROMETHANE	9	9	0	0	1	25	2.5			
BROMODICHLOROMETHANE	9	9	0	0	1	25	2.5			
BROMOFORM	9	9	0	0	1	25	2.5			
BROMOMETHANE	9	9	0	0	1	25	2.5			
CARBON TETRACHLORIDE	9	9	0	0	1	25	2.5			
CHLOROBENZENE	9	9	0	0	1	25	2.5			
CHLOROETHANE	9	9	0	0	1	25	2.5			
CHLOROFORM	9	9	0	0	1	25	2.5			
CHLOROMETHANE	9	8	1	11.1	1	25	2.5	0.6	0.6	0.6
CIS-1,2-DICHLOROETHENE	9	9	0	0	1	25	2.5			
CIS-1,3-DICHLOROPROPENE	9	9	0	0	1	25	2.5			
CUMENE	9	2	7	77.8	1	25	2.4	0.3	1.1	2

Table 4-8 (Page 3 of 4)
Summary Statistics of the Volatile Organic Compounds Monitoring Well Data

Analyte	Number of Samples			Percent Detects	Reporting Limits for Nondetects (µg/L)		Overall Mean (µg/L)	Detected Concentrations (µg/L)		
	Total	Nondetects	Detects		Minimum	Maximum		Minimum	Mean	Maximum
DIBROMOCHLOROMETHANE	9	9	0	0	1	25	2.5			
DIBROMOMETHANE	9	9	0	0	1	25	2.5			
DICHLORODIFLUOROMETHANE	9	9	0	0	1	25	2.5			
ETHYLBENZENE	9	0	9	100			33	2	33	112
HEXACHLOROBUTADIENE	9	9	0	0	1	25	2.5			
METHANE	9	0	9	100			9977	1900	9977	32000
METHYLENE CHLORIDE	9	8	1	11.1	1	25	2.4	2	2	2
N-BUTYLBENZENE	9	9	0	0	1	25	2.5			
N-PROPYLBENZENE	9	4	5	55.6	1	25	2.2	0.2	0.8	2
NAPHTHALENE	9	5	4	44.4	0.4	7.9	294	10	659	2400
P-ISOPROPYLTOLUENE	9	9	0	0	1	25	2.5			
SEC-BUTYLBENZENE	9	9	0	0	1	25	2.5			
STYRENE	9	8	1	11.1	1	25	8.6	57	57	57
TERT-BUTYLBENZENE	9	9	0	0	1	25	2.5			
TETRACHLOROETHENE	9	9	0	0	1	25	2.5			
TOLUENE	9	2	7	77.8	1	1	34	2	44	140
TRANS-1,3-DICHLOROPROPENE	9	9	0	0	1	25	2.5			
TRICHLOROETHENE	9	9	0	0	1	25	2.5			
TRICHLOROFLUOROMETHANE	9	9	0	0	1	25	2.5			

Table 4-8 (Page 4 of 4)
Summary Statistics of the Volatile Organic Compounds Monitoring Well Data

Analyte	Number of Samples			Percent Detects	Reporting Limits for Nondetects (µg/L)		Overall Mean (µg/L)	Detected Concentrations (µg/L)		
	Total	Nondetects	Detects		Minimum	Maximum		Minimum	Mean	Maximum
VINYL CHLORIDE	9	9	0	0	1	25	2.5			
XYLENE (TOTAL)	9	1	8	88.9	1	1	30	2.1	33	120

µg/L denotes microgram(s) per liter

MTBE denotes methyl tertiary butyl ether

The overall mean is calculated using the nondetects and detects (see Section 4.1.1).

Well P181-MW46. Detected PAHs generally follow the same distribution pattern as benzene and naphthalene.

The source of the benzene and other VOCs and PAH compounds in groundwater is uncertain; however, the isoconcentrations shown in Figures 4-41, 4-42, 4-45, and 4-46 suggest a potential source or sources at two possible locations. The first is within the general vicinity of Parcel 176, which is the former Fleet and Industrial Supply Center Oakland (FISCO) Annex Scrapyard, and Parcels 173 and 175. Both the benzene and naphthalene isoconcentration contours show an area of high concentration centered here. The second potential source area is in the southeast corner of Parcel 181 near Kollmann Circle, where another area of high concentration is evident from the direct-push groundwater sampling results. Historical aerial photographs show a stained soil area here (see Figures 1-2 and 2-2). Either one or both of these locations could be the potential source areas for the VOCs and PAHs found in groundwater samples.

The distribution of VOCs in the groundwater was evaluated to determine if either one of the two high concentration areas had a unique set of compounds such as solvents. However, there were only slight distinguishing chemical characteristics between these areas. The concentration of 1,2-dichloroethane is more consistent with the site of the former FISCO Annex Scrapyard than the area near Kollmann Circle. The fact that no chemicals are unique to either area suggests that there is a common source or at least a common source material or maybe that the chemicals have been there a long time.

The source material for the VOCs and PAHs is unclear. While both high concentration areas have had historical industrial activities, including evidence of soil staining, the characteristics of the VOCs, PAHs, and total petroleum hydrocarbon (TPH) (although not evaluated in this OU-5 RI) in groundwater are largely similar to those associated with historical activities in the area. Low concentrations of MTBE in groundwater near the FISCO Annex area suggest that there may be additional sources of contamination, in addition to contamination associated with historical activities. In addition, the fact that 1,2-dichloroethane is present suggests a potential recent release of a fuel such as gasoline.

The Navy has decided, based on the OU-5 groundwater data, that groundwater would be defined as a separate OU, and that a separate RI will be developed to address groundwater in this region, including the plume detected under a portion of OU-5.

4.3 Natural Attenuation Information

Natural attenuation parameters of chemicals in groundwater were evaluated during this RI. These "lines of evidence" are defined in the *Standard Guide for Remediation of Groundwater by Natural Attenuation at Petroleum Release Sites* (ASTM, 1998) and the *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Water* (AFCEE, 1995). These "lines of evidence" are necessary for demonstrating the appropriateness of remediation by natural attenuation. The primary "line of evidence" is generally considered enough to demonstrate natural attenuation at the site is a viable remedial alternative, but secondary lines of evidence are required when the monitoring data are limited or are not conclusive.

Natural attenuation is the reduction in concentration and mass of a contaminant plume due to processes occurring naturally in the environment. Natural attenuation occurs through a combination of physical, chemical, and biological processes, including volatilization, dispersion, dilution, sorption, and biodegradation (also known as intrinsic bioremediation). All of these processes contribute to a measurable reduction of the concentrations of contaminants within the plume. However, biodegradation is the only process that can produce significant reduction of the total mass of the contaminant plume via conversion of the hydrocarbons into carbon dioxide and water (Buscheck, et al., 1996).

Hydrocarbon biodegradation is a series of microbially mediated chemical reactions that produce changes in the ambient geochemistry of the groundwater in which the reactions occur (AFCEE, 1995). The occurrence of biodegradation is indicated by measured trends in several geochemical parameters. In general, any of the following trends observed within a dissolved petroleum hydrocarbon plume would suggest the occurrence of natural biodegradation:

- A relative *decrease* in:
  - Dissolved oxygen
  - Oxidation-reduction potential
  - Nitrate
  - Sulfate

- A relative *increase* in:
  - Ferrous iron
  - Alkalinity
  - Methane
  - Sulfide

Relative decreases and increases in the corresponding parameters at a petroleum hydrocarbon plume are considered as primary lines of evidence. In the case of this RI, TPHs were not measured. However, BTEX constituents, which are a major component of TPH were analyzed and are thereby appropriate for evaluation of a petroleum hydrocarbon plume.

Additionally when you have mixed plumes of chloroethenes and petroleum, the petroleum acts as a food source for the bacteria. These bacteria can degrade the chloroethenes. There are indications that sequential degradation daughter products, such as dichloroethene, are present.

Dissolved oxygen is the most thermodynamically favored electron acceptor used in the biodegradation of petroleum hydrocarbons (AFCEE, 1995). Aerobic biodegradation decreases the available dissolved oxygen in the groundwater and provides one of the best indicators of fuel biodegradation.

Oxidation-reduction (redox) potential of groundwater is a measure of the electron activity and indicates the relative tendency of a solution to accept or transfer electrons (AFCEE, 1995). Redox reactions in petroleum-hydrocarbon-contaminated groundwater are usually biologically mediated; therefore, the redox potential of a groundwater system depends upon and influences rates of biodegradation. Redox potentials within the plume are generally lower than those outside the plume and are often correlative with dissolved oxygen concentrations. The areas where oxygen has been depleted by biodegradation tend to have the lowest redox potentials.

After the dissolved oxygen is depleted by biodegradation, nitrate, iron, and sulfate may be used as electron acceptors for anaerobic biodegradation. Utilization of nitrate as a nutrient during biodegradation can produce a marked decrease of nitrate in wells screened within the hydrocarbon plume. Utilization of ferric iron and sulfate for anaerobic degradation produces ferrous iron and sulfide, respectively. An increase in these parameters (above background concentrations) within the plume provides another indicator of biodegradation.

Methanogenesis is another biodegradation process that can occur under anaerobic conditions. This process generally occurs after oxygen, nitrate, ferric iron, and sulfate have been depleted by biodegradation (AFCEE, 1995). During methanogenesis, carbon dioxide is used as an electron acceptor and methane is produced. The presence of methane in groundwater within the plume provides an indication of microbial degradation when concentrations exceed background. However, methane is also produced during the decay of vegetation such as the organic rich marsh crust.

Alkalinity variations across the hydrocarbon plume can also provide evidence of biodegradation. Alkalinity tends to be higher in wells located within the hydrocarbon plume than those positioned outside the plume because the oxygen in the groundwater (in the form of oxygen, nitrate, iron (II) hydroxide, or sulfate) is biologically converted to carbon dioxide. The carbon dioxide then combines for instance with other ions (i.e., hydrogen carbonate) thus increasing alkalinity.

Other parameters (i.e., secondary lines of evidence) that provide useful information about biodegradation include pH and temperature. These parameters do not provide direct evidence that biodegradation is occurring, but indicate if the physical and chemical conditions of the groundwater system are conducive to biodegradation. For example, biodegradation operates best when the pH is between six and eight and the groundwater temperature is between 16 and 20 degrees Celsius (Buscheck and O'Reilly, 1995).

The geochemical indicators (dissolved oxygen, oxidation-reduction potential, nitrate, sulfate, sulfide, ferrous iron, alkalinity, and methane) were collected during the RI to provide potential secondary lines of evidence. A summary of the natural attenuation parameter measurements is presented in Table 4-9, "Summary of Natural Attenuation Parameter Measurements." Detailed interpretation is not possible with the limited data set. However, additional data will be collected quarterly as part of the regular basewide groundwater monitoring program and presented in the quarterly groundwater monitoring reports.

4.4 Spatial Distribution of Chemicals in Soil Gas

Soil gas results for VOCs and naphthalene are summarized in Table 4-10, "Summary Statistic of the Soil Gas Data by Depth" and are shown on Figures 4-66 through 4-69. Soil gas samples were collected from the approximate 2 feet bgs and 5 to 7 feet bgs depths. The actual length of the exposed screen through which the sample was collected was approximately 1 inch. All soil gas sampling locations except two (OU5-SG8 and OU5-SG15) were located adjacent (within 5 feet) to a direct-push sample location. The two soil gas sampling locations that were not co-located were positioned to provide improved spatial distribution of the soil gas samples. Tables 4-11 through 4-13 present the co-located groundwater direct-push and soil gas sampling locations and results for benzene, naphthalene, and MTBE. Section 3.4.3 provides a detailed discussion of the soil gas sampling methods.

Five cross-sectional views of benzene, naphthalene, and MTBE concentrations in groundwater and soil gas are provided on Figures 4-70 through 4-84. These concentration views were overlade onto corresponding geologic cross sections (see Figures 4-2 through 4-6). Soil gas

Table 4-9 (Page 1 of 3)
Summary of Natural Attenuation Parameter Measurements

Boring Location	Sample Depth [1] (ft bgs)	Dissolved Oxygen (ppm)	Oxidation/ Reduction Potential (millivolts)	Ferrous Iron (ppm)		Methane (mg/L)	Nitrate (mg/L)		Sulfate (mg/L)		Sulfide (mg/L)		Alkalinity (mg/L)	Benzene (mg/L)	
OS-HP-04	12-16	NM	-214		2.5	2800	5		70		1.6		3530	12	
	16-20	NM	-172	>	10.0	4200	6		60		0.2	U	3960	45	
OS-HP-06	6-10	NM	NM		NM	1200	0.8	U	28	U	0.2	U	260	1	U
	10-14	NM	NM		NM	6800	0.8	U	10	U	0.2	U	260	148	
OS-HP-10	6-10	8.31	-10		NM	9200	2	U	340		3.2		3280	4.2	J
	9-13	0.53	-125		NM	NM	NM		NM		NM		NM	2.4	
	14-18	1.77	-123		NM	NM	NM		NM		NM		NM	6000	J
OS-HP-14	12-16	NM	-187		NM	7200	7		50	U	2.9		3640	742	
	16-19	NM	-151		NM	NR	NR		NR		NR		NR	1970	
OS-HP-20	16-20	NM	-128		10.0	3000	0.1	U	1800		1.9		3280	17	
OS-HP-25	12-16	19.99	-145		1.0	160	0.1	U	175		1	U	400	2	UJ
	16-20	2.74	-168		10.0	2100	0.1	U	0.76		1		1740	270	J
OS-HP-28	8-12	NM	-77		1.6	4400	0.1	U	0.47	J	2.08		374	2	U
	12-16	NM	-172		2.6	4700	0.1	U	0.46	J	5.69		426	2	U
	16-20	0.93	-175	>	10.0	7000	0.1	U	0.56	J	1.99		1720	0.24	J
	20-24	1.0	-183	>	10.0	3200	2.5	U	0.33	J	3.79		2770	2	U
OS-HP-30	12-16	7.87	-143		NM	NM	NM		NM		NM		NM	21	

Table 4-9 (Page 2 of 3)
Summary of Natural Attenuation Parameter Measurements

Boring Location	Sample Depth [1] (ft bgs)	Dissolved Oxygen (ppm)	Oxidation/ Reduction Potential (millivolts)	Ferrous Iron (ppm)		Methane (mg/L)	Nitrate (mg/L)		Sulfate (mg/L)		Sulfide (mg/L)		Alkalinity (mg/L)	Benzene (mg/L)	
OS-HP-37	6-10	6.61	-51		4.2	2000	0.8	U	27		0.2	U	478	1	U
	10-14	0.94	-143		1.2	1100	0.2	U	57		0.2	U	465	39	
	14-18	3.52	-118	>	10.0	6800	4	U	50	U	0.2	U	1740	1770	
OU5-HP-01	6-10	4.75	-128		4.1	850	0.1	U	540	J	1	U	262	1	U
	10-14	3.27	-160		10.0	2800	0.1	U	110	J	1	U	1660	37	
	14-18	1.43	-156	>	10.0	5300	20	U	0.36	J	1		3690	3.8	
OU5-HP-06	6-10	NM	-49		NM	390	0.5	U	98		1	U	379	2	U
	10-14	NM	-137	>	10.0	1300	0.5	U	140		1.8		636	9.1	
	14-18	NM	-138	>	10.0	5800	0.44	J	0.34	J	2.62		2410	110	J
OU5-HP-10	8-10	NM	-116	>	10.0	1500	0.5	U	1200		1	U	164	2	U
	10-14	NM	-93	>	10.0	1400	0.5	U	1200		1	U	636	5.9	
	14-18	NM	-131	>	10.0	3800	0.5	U	0.79		2.4		3030	180	J
OU5-HP-13	8-12	3.62	-190		2.6	2100	0.1	U	3.7		1.08	J	274	2	U
	12-15	5.25	-178		2.8	6700	0.1	U	0.86		1	UJ	974	560	J
	15-17.5	1.52	-140	>	10.0	5700	0.1	U	0.51		1.99	J	1990	4100	J
OU5-HP-14	6-10	NM	-181	>	10.0	53	0.5	U	690		1	U	461	2	U
	10-14	NM	-110	>	10.0	4700	0.5	U	140		1.62		1040	2	U
	14-18	NM	NM		NM	5100	NM		NM		NM		NM	2	U

Table 4-9 (Page 3 of 3)
Summary of Natural Attenuation Parameter Measurements

Boring Location	Sample Depth [1] (ft bgs)	Dissolved Oxygen (ppm)	Oxidation/ Reduction Potential (millivolts)	Ferrous Iron (ppm)		Methane (mg/L)	Nitrate (mg/L)		Sulfate (mg/L)		Sulfide (mg/L)		Alkalinity (mg/L)	Benzene (mg/L)	
OU5-HP-17	6-10	3.77	-49		3.0	20	0.4	U	266		0.2	U	270	1	U
	10-14	8.42	-142		4.1	780	0.4	U	150		0.2	U	469	1	U
	14-18	2.56	-165	>	10.0	8400	4	U	50	U	0.2	U	2610	2	
OU5-HP-20	6-10	4.08	-113		2.4	310	0.1	U	13		0.2	U	280	0.4	J
	10-14	2.89	-79		2.0	1300	0.2	U	8		0.2	U	999	1	U
	15-19	1.24	-160		3.0	10000	4	U	50	U	0.2	U	999	1	U
EW-02	3.0-18.0	NM	-224		2.0	1910	0.4	U	8		4		1910	673	
P181-MW45	16-18.5	NM	-139		7.6	11000	0.16	U	3		0.2	U	2780	134	
P181-MW46	9-19	NM	-110		4.4	7200	0.4	U	54		0.2	J	2820	1	U
P181-MW47	13.5-18.5	NM	-128		4.6	10000	0.2	U	2.5	U	0.1	J	1800	1620	
PW-12	12.0-17.0	NM	-156		8.2	3370	0.2	U	540		0.2	U	3370	29	
S-12	4.0-19.0	NM	-70		2.4	3900	0.2	U	49		0.2	U	552	37	
S-13	3.5-13.5	NM	-337		0	12000	2	U	170		4.1		1740	38	
S-16	3.7-13.7	NM	-186		0.6	9200	2	U	340		3.2		3280	9.6	
S-35	3.5-18.5	NM	54		0	1900	0.25		16		0.2	U	621	38	

[1] Sampling interval for direct-push samples and screened interval for monitoring wells

ft bgs denotes feet below ground surface

mg/L denotes milligram(s) per liter

U denotes not detected above the listed value

NM denotes not measured due to equipment failure

ppm denotes parts per million

> denotes greater than listed value

J denotes estimated value

Table 4-10 (Page 1 of 4)
Summary Statistics of the Soil Gas Data by Depth

Analyte	Depth Interval (feet bgs)	Number of Samples			Percent Detects	Reporting Limits for Non-Detects (µg/m³)		Detected Concentrations (µg/m³)	
		Total	Non-Detects	Detects		Minimum	Maximum	Minimum	Maximum
1,1,1-TRICHLOROETHANE	2	30	25	5	16.7	2	4	3.1	27
1,1,1-TRICHLOROETHANE	5	11	11	0	0	2	6		
1,1,2,2-TETRACHLOROETHANE	2	30	30	0	0	2	10		
1,1,2,2-TETRACHLOROETHANE	5	11	11	0	0	2	6		
1,1,2-TRICHLOROETHANE	2	30	30	0	0	2	10		
1,1,2-TRICHLOROETHANE	5	11	11	0	0	2	6		
1,1-DICHLOROETHANE	2	30	29	1	3.3	2	10	38	38
1,1-DICHLOROETHANE	5	11	10	1	9.1	2	6	6	6
1,1-DICHLOROETHENE	2	30	30	0	0	2	10		
1,1-DICHLOROETHENE	5	11	10	1	9.1	2	6	3.9	3.9
1,2-DICHLOROETHANE	2	30	30	0	0	2	10		
1,2-DICHLOROETHANE	5	11	11	0	0	2	6		
1,2-DICHLOROPROPANE	2	30	30	0	0	2	10		
1,2-DICHLOROPROPANE	5	11	11	0	0	2	6		
2-BUTANONE (METHYL ETHYL KETONE)	2	30	3	27	90	2	10	2.6	240
2-BUTANONE (METHYL ETHYL KETONE)	5	11	1	10	90.9	2	2	2.7	30
2-HEXANONE	2	30	28	2	6.7	2	10	4.1	29
2-HEXANONE	5	11	11	0	0	2	6		

Table 4-10 (Page 2 of 4)
Summary of Statistics of the Soil Gas Data by Depth

Analyte	Depth Interval (feet bgs)	Number of Samples			Percent Detects	Reporting Limits for Non-Detects (µg/m³)		Detected Concentrations (µg/m³)	
		Total	Non-Detects	Detects		Minimum	Maximum	Minimum	Maximum
4-METHYL-2-PENTANONE (MIBK)	2	30	10	20	66.7	2	10	2.9	19
4-METHYL-2-PENTANONE (MIBK)	5	11	3	8	72.7	2	2	3.6	78
ACETONE	2	30	3	27	90	2	2	20	310
ACETONE	5	11	2	9	81.8	2	2	12	140
BENZENE	2	30	15	15	50	2	10	2.5	20
BENZENE	5	11	4	7	63.6	2	2	3.1	15
BROMODICHLOROMETHANE	2	30	30	0	0	2	10		
BROMODICHLOROMETHANE	5	11	11	0	0	2	6		
BROMOFORM	2	30	30	0	0	2	10		
BROMOFORM	5	11	11	0	0	2	6		
BROMOMETHANE	2	30	30	0	0	2	10		
BROMOMETHANE	5	11	11	0	0	2	6		
CARBON TETRACHLORIDE	2	30	30	0	0	2	10		
CARBON TETRACHLORIDE	5	11	11	0	0	2	6		
CHLOROBENZENE	2	30	29	1	3.3	2	10	28	28
CHLOROBENZENE	5	11	11	0	0	2	6		
CHLOROETHANE	2	30	29	1	3.3	2	10	5.2	5.2
CHLOROETHANE	5	11	11	0	0	2	6		
CHLOROFORM	2	30	13	17	56.7	2	4	2.5	92

Table 4-10 (Page 3 of 4)
Summary of Statistics of the Soil Gas Data by Depth

Analyte	Depth Interval (feet bgs)	Number of Samples			Percent Detects	Reporting Limits for Non-Detects (µg/m³)		Detected Concentrations (µg/m³)	
		Total	Non-Detects	Detects		Minimum	Maximum	Minimum	Maximum
CHLOROFORM	5	11	8	3	27.3	2	6	2.5	35
CHLOROMETHANE	2	30	30	0	0	2	10		
CHLOROMETHANE	5	11	11	0	0	2	6		
CIS-1,2-DICHLOROETHENE	2	30	30	0	0	2	10		
CIS-1,2-DICHLOROETHENE	5	11	9	2	18.2	2	6	4	19
CIS-1,3-DICHLOROPROPENE	2	30	30	0	0	2	10		
CIS-1,3-DICHLOROPROPENE	5	11	11	0	0	2	6		
DIBROMOCHLOROMETHANE	2	30	30	0	0	2	10		
DIBROMOCHLOROMETHANE	5	11	11	0	0	2	6		
ETHYLBENZENE	2	30	1	29	96.7	2	2	2.8	390
ETHYLBENZENE	5	11	0	11	100			7.8	290
M,P-XYLENE	2	30	0	30	100			14	2000
M,P-XYLENE	5	11	0	11	100			15	420
METHYL TERT-BUTYL ETHER (MTBE)	2	30	12	18	60	2	10	6.6	77
METHYL TERT-BUTYL ETHER (MTBE)	5	11	3	8	72.7	2	2	6.9	170
METHYLENE CHLORIDE	2	30	30	0	0	2	10		
METHYLENE CHLORIDE	5	11	11	0	0	2	6		
NAPHTHALENE	2	30	2	28	93.3	2	10	2.1	54
NAPHTHALENE	5	11	0	11	100			4.3	180

Table 4-10 (Page 4 of 4)
Summary of Statistics of the Soil Gas Data by Depth

Analyte	Depth Interval (feet bgs)	Number of Samples			Percent Detects	Reporting Limits for Non-Detects (µg/m³)		Detected Concentrations (µg/m³)	
		Total	Non-Detects	Detects		Minimum	Maximum	Minimum	Maximum
O-XYLENE	2	30	0	30	100			6.6	810
O-XYLENE	5	11	0	11	100			9.2	360
STYRENE	2	30	26	4	13.3	2	10	2.9	7.2
STYRENE	5	11	11	0	0	2	6		
TETRACHLOROETHENE	2	30	20	10	33.3	2	4	3.5	65
TETRACHLOROETHENE	5	11	8	3	27.3	2	6	3.3	86
TOLUENE	2	30	1	29	96.7	10	10	6.2	230
TOLUENE	5	11	0	11	100			7.2	300
TRANS 1,3-DICHLOROPROPENE	2	30	30	0	0	2	10		
TRANS 1,3-DICHLOROPROPENE	5	11	11	0	0	2	2		
TRANS-1,2-DICHLOROETHENE	2	30	30	0	0	2	10		
TRANS-1,2-DICHLOROETHENE	5	11	11	0	0	2	6		
TRICHLOROETHENE	2	30	27	3	10	2	4	4.3	130
TRICHLOROETHENE	5	11	11	0	0	2	2		
VINYL ACETATE	2	30	26	4	13.3	2	10	8.8	76
VINYL ACETATE	5	11	11	0	0	2	2		

µg/m³ denotes microgram(s) per cubic meter
bgs denotes below ground surface
MIBK denotes methyl isobutyl ketone

IMAGE	X-REF	OFFICE	DRAWN BY
---	ALA1BASE	CONCORD	RB 12-5-02

CHECKED BY		APPROVED BY	DRAWING NUMBER
AR 12/5/02		JES 12/5/02	819814-B57

LEGEND

———	OU5 BOUNDARY
181	PARCEL NUMBER
———	PARCEL BOUNDARY
⊙ OS-SG3	SOIL GAS SAMPLING LOCATION
OS	OFF SITE LOCATION
OU5	OPERABLE UNIT 5 LOCATION
4.9	BENZENE CONCENTRATION IN MICROGRAMS PER CUBIC METER
NR	NO RECOVERY FROM SAMPLED DEPTH
NA	SAMPLE NOT ANALYZED, OBSTRUCTION IN SUMMA CANISTER VALUE
2U	NOT DETECTED ABOVE LISTED VALUE

SCALE

0 300 600 FEET

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4-66

SOIL GAS BENZENE RESULTS
2 FT DEPTH

IMAGE	X-REF	OFFICE	DRAWN BY
---	ALA1BASE	CONCORD	RB 12-5-02

CHECKED BY		APPROVED BY	DRAWING NUMBER
		JES 12/5/02	819814-B58

LEGEND

———	OU5 BOUNDARY
181	PARCEL NUMBER
———	PARCEL BOUNDARY
⊙ OS-SG3	SOIL GAS SAMPLING LOCATION
OS	OFF SITE LOCATION
OU5	OPERABLE UNIT 5 LOCATION
13	BENZENE CONCENTRATION IN MICROGRAMS PER CUBIC METER
NR	NO RECOVERY FROM SAMPLED DEPTH
2.0U	NOT DETECTED ABOVE LISTED VALUE

SCALE

0 300 600 FEET

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4-67

SOIL GAS BENZENE RESULTS
5-7 FT DEPTH

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	RB	12-5-02	JES	819814-B55

LEGEND

———	OU5 BOUNDARY
181	PARCEL NUMBER
———	PARCEL BOUNDARY
⊙ OS-SG3	SOIL GAS SAMPLING LOCATION
OS	OFF SITE LOCATION
OU5	OPERABLE UNIT 5 LOCATION
4.9	NAPHTHALENE CONCENTRATION IN MICROGRAMS PER CUBIC METER
NR	NO RECOVERY FROM SAMPLED DEPTH
NA	SAMPLE NOT ANALYZED, OBSTRUCTION IN SUMMA CANISTER VALUE
2U	NOT DETECTED ABOVE LISTED VALUE

SCALE

0 300 600 FEET

OPERABLE UNIT 5
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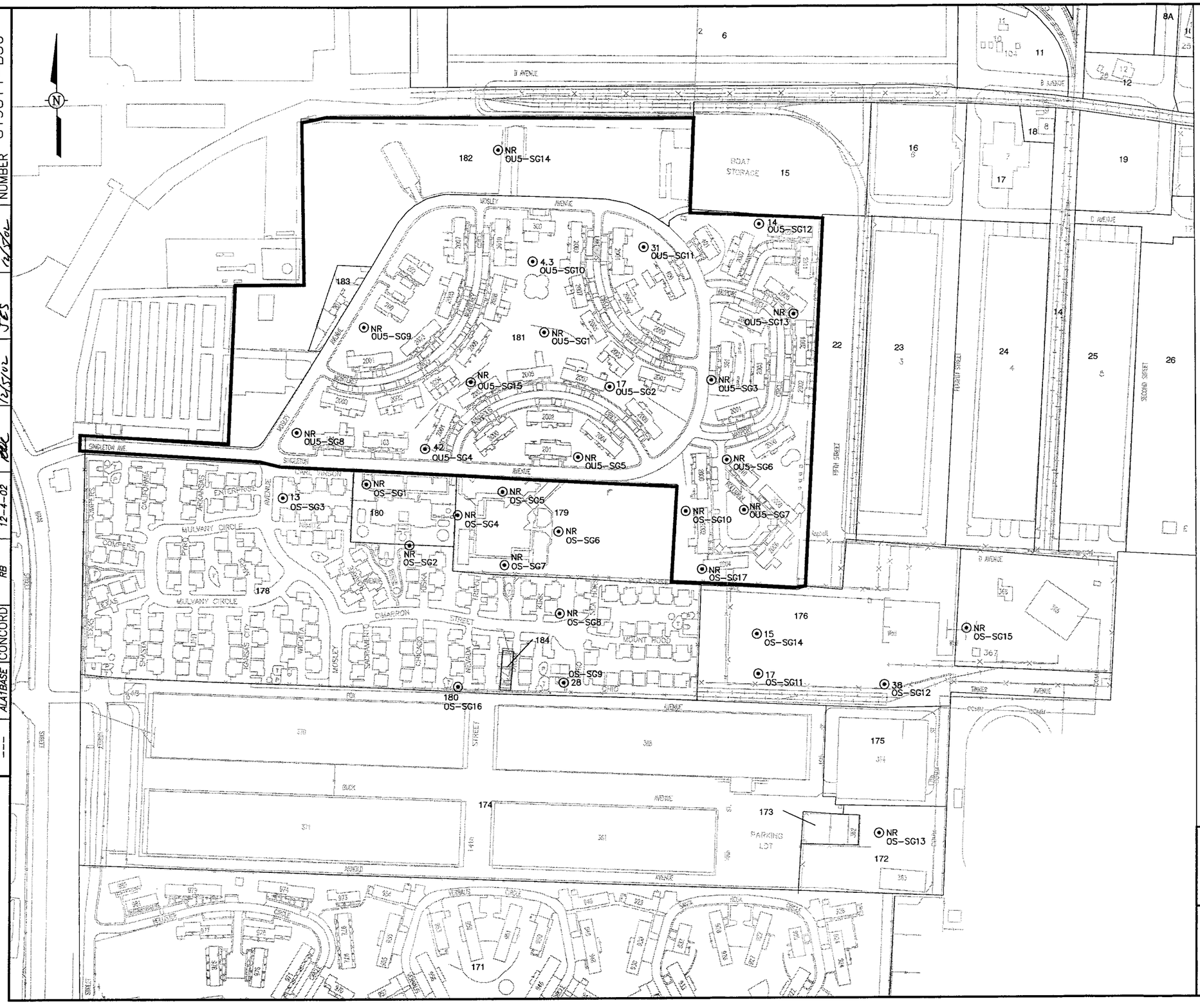
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4-68

SOIL GAS NAPHTHALENE RESULTS
2 FT DEPTH

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	RB 12-4-02	DRC 12/5/02	JES 12/5/02	819814-B56



LEGEND

———	OU5 BOUNDARY
181	PARCEL NUMBER
———	PARCEL BOUNDARY
⊙ OS-SG3	SOIL GAS SAMPLING LOCATION
OS	OFF SITE LOCATION
OU5	OPERABLE UNIT 5 LOCATION
4.9	NAPHTHALENE CONCENTRATION IN MICROGRAMS PER CUBIC METER
NR	NO RECOVERY FROM SAMPLED DEPTH

SCALE

0 300 600 FEET

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4-69

SOIL GAS NAPHTHALENE RESULTS
5-7 FT DEPTH

Table 4-11 (Page 1 of 2)
Benzene Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Sample Location	Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OU5-HP1	ND	ND	3.2	NS	OU5-SG1	ND	NS
OU5-HP9	ND	ND	ND	NS	OU5-SG2	NS	1.0
OU5-HP11	ND	76	22	NS	OU5-SG3	ND	NS
OU5-HP4	ND	37	NS	NS	OU5-SG4	2.1	1.6
OU5-HP8	ND	49	49	NS	OU5-SG5	0.9	NS
OU5-HP12	ND	1	640	NS	OU5-SG6	ND	NS
OU5-HP13	ND	560J	4100J	NS	OU5-SG7	ND	NS
OU5-HP14	ND	ND	ND	NS	OU5-SG9	1.4	NS
OU5-HP17	ND	ND	2	NS	OU5-SG10	NA	4.0
OU5-HP18	ND	ND	ND	ND	OU5-SG11	ND	ND
OU5-HP20	0.4J	ND	ND	NS	OU5-SG12	2.2	ND
OU5-HP21	ND	ND	ND	NS	OU5-SG13	2.0	NS
OU5-HP22	ND	ND	NS	NS	OU5-SG14	ND	NS
OS-HP2	41	210	NS	NS	OS-SG1	6.2	NS
OS-HP3	NS	ND	72	NS	OS-SG2	ND	NS
OS-HP6	ND	148	NS	NS	OS-SG4	ND	NS
OS-HP7	NS	375	351	NS	OS-SG5	ND	NS
OS-HP8	ND	ND	670	NS	OS-SG6	ND	NS
OS-HP9	ND	17	220	NS	OS-SG7	ND	NS
OS-HP21	NS	0.6J	8.8	NS	OS-SG8	ND	NS
OS-HP20	NS	NS	17	NS	OS-SG9	2.5	ND
OS-HP10	4.2J	2.4	6000J	NS	OS-SG10	ND	NS
OS-HP17	ND	ND	645	NS	OS-SG11	1.4	1.2
OS-HP14	NS	742	1970	NS	OS-SG12	1.2	4.3
OS-HP39	NS	90J	NS	NS	OS-SG13	ND	NS
OS-HP35	NS	NS	230J	NS	OS-SG-14	1.5	4.6

Table 4-11 (Page 2 of 2)
Benzene Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Sample Location	Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OS-HP4	NS	12	45	NS	OS-SG15	1.3	NS
OS-HP22	NS	NS	8.8	NS	OS-SG16	0.8	3.1
OS-HP37	ND	39	1770	NS	OS-SG17	1.0	NS

Note: No soil gas and direct-push samples were collected from the same boring. Co-located means laterally within 5 feet of each boring.

µg/L denotes microgram(s) per liter

NA denotes not applicable

ND denotes not detected above minimum detection limit

NS denotes no sampled attempted or no recovery

ppbv denotes parts per billion volume

J denotes estimated value

Table 4-12 (Page 1 of 2)
Naphthalene Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Groundwater Sample Location	Groundwater Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OU5-HP1	ND	1.2J	20	NS	OU5-SG1	3.9	NS
OU5-HP9	ND	ND	ND	NS	OU5-SG2	NS	3.2
OU5-HP11	5	5660	1070	NS	OU5-SG3	4.1	NS
OU5-HP4	ND	2530	NS	NS	OU5-SG4	10.1	7.9
OU5-HP8	ND	1200J	750	NS	OU5-SG5	1.7	NS
OU5-HP12	14	21	6220	NS	OU5-SG6	2.6	NS
OU5-HP13	2.3	3700J	13000	NS	OU5-SG7	3.4	NS
OU5-HP14	ND	1.6J	1.2J	NS	OU5-SG9	0.4	NS
OU5-HP17	2.2	2	29	NS	OU5-SG10	NA	0.8
OU5-HP18	0.79J	ND	ND	29	OU5-SG11	4.5	5.8
OU5-HP20	27	5.7	10	NS	OU5-SG12	3.2	2.6
OU5-HP21	21	7.3	3.3	NS	OU5-SG13	3.2	NS
OU5-HP22	ND	ND	NS	NS	OU5-SG14	2.3	NS
OS-HP2	270	3040	NS	NS	OS-SG1	2.1	NS
OS-HP3	NS	0.6J	970J	NS	OS-SG2	ND	NS
OS-HP6	2.6	1350	NS	NS	OS-SG4	2.3	NS
OS-HP7	NS	3180	4530	NS	OS-SG5	ND	NS
OS-HP8	4.4	2.7	6130	NS	OS-SG6	3.4	NS
OS-HP9	30	129	1770	NS	OS-SG7	0.7	NS
OS-HP21	NS	0.7J	NS	NS	OS-SG8	0.9	NS
OS-HP20	NS	NS	210J	NS	OS-SG9	3.2	5.3
OS-HP10	49	14	12000J	NS	OS-SG10	2.6	NS
OS-HP17	ND	23	3970	NS	OS-SG11	2.4	3.2
OS-HP14	NS	3710	5320	NS	OS-SG12	3.6	7.1
OS-HP39	NS	1200J	NS	NS	OS-SG13	8.3	NS
OS-HP35	NS	NS	3400J	NS	OS-SG-14	2.4	2.8
OS-HP4	NS	839	821	NS	OS-SG15	3.6	NS

Table 4-12 (Page 2 of 2)
Naphthalene Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Groundwater Sample Location	Groundwater Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OS-HP22	NS	NS	370J	NS	OS-SG16	3.6	33.8
OS-HP37	4.9	212	8040	NS	OS-SG17	1.7	NS

Note: No soil gas and direct-push samples were collected from the same boring. Co-located means laterally within 5 feet of each boring.

µg/L denotes microgram(s) per liter

NA denotes not applicable

ND denotes not detected above minimum detection limit

NS denotes no sampled attempted or no recovery

ppbv denotes parts per billion volume

J denotes estimated value

Table 4-13 (Page 1 of 2)
Methyl-Tertiary-Butyl-Ether Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Groundwater Sample Location	Groundwater Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OU5-HP1	ND	ND	ND	NS	OU5-SG1	ND	NS
OU5-HP9	ND	ND	ND	NS	OU5-SG2	ND	10.9
OU5-HP11	1J	1J	0.8J	NS	OU5-SG3	7.9	NS
OU5-HP4	0.8J	ND	NS	NS	OU5-SG4	9.6	8.5
OU5-HP8	ND	ND	ND	NS	OU5-SG5	1.8	NS
OU5-HP12	1J	0.8J	ND	NS	OU5-SG6	5.2	NS
OU5-HP13	ND	ND	ND	NS	OU5-SG7	6.3	NS
OU5-HP14	ND	ND	ND	NS	OU5-SG9	16.9	NS
OU5-HP17	ND	ND	ND	NS	OU5-SG10	NS	ND
OU5-HP18	0.56J	ND	ND	ND	OU5-SG11	7.6	8.2
OU5-HP20	0.2J	0.9J	ND	NS	OU5-SG12	21	5.7
OU5-HP21	0.7J	0.6J	1J	NS	OU5-SG13	20.5	NS
OU5-HP22	0.8J	0.7J	NS	NS	OU5-SG14	ND	NS
OS-HP2	ND	ND	NS	ND	OS-SG1	ND	NS
OS-HP3	NS	0.3J	ND	NS	OS-SG2	ND	NS
OS-HP6	ND	ND	NS	NS	OS-SG4	ND	NS
OS-HP7	ND	ND	NS	NS	OS-SG5	ND	NS
OS-HP8	ND	ND	ND	NS	OS-SG6	ND	NS
OS-HP9	ND	ND	ND	NS	OS-SG7	ND	NS
OS-HP21	NS	1J	NS	NS	OS-SG8	ND	NS
OS-HP20	NS	NS	ND	NS	OS-SG9	ND	ND
OS-HP10	ND	ND	ND	NS	OS-SG10	7.1	NS
OS-HP17	0.7J	0.6J	2J	NS	OS-SG11	7.1	8.7
OS-HP14	NS	ND	1J	NS	OS-SG12	8.2	17.5
OS-HP39	NS	ND	NS	NS	OS-SG13	9.3	NS
OS-HP35	NS	NS	0.77J	NS	OS-SG-14	9	46.4

Table 4-13 (Page 2 of 2)
Methyl-Tertiary-Butyl-Ether Analytical Results Summary for Co-Located Groundwater Direct-Push and Soil Gas Sampling Locations

Direct-Push Groundwater Sample Location	Groundwater Analytical Results (µg/L)				Soil Gas Sample Location	Soil Gas Analytical Results (ppbv)	
	8-12 ft bgs	12-16 ft bgs	16-20 ft bgs	20-24 ft bgs		2 ft bgs	5 to 7 ft bgs
OS-HP4	NS	ND	ND	NS	OS-SG15	9	NS
OS-HP22	NS	NS	ND	NS	OS-SG16	ND	1.9
OS-HP37	0.3J	ND	ND	NS	OS-SG17	2	NS

Note: No soil gas and direct-push samples were collected from the same boring. Co-located means laterally within 5 feet of each boring.

µg/L denotes microgram(s) per liter

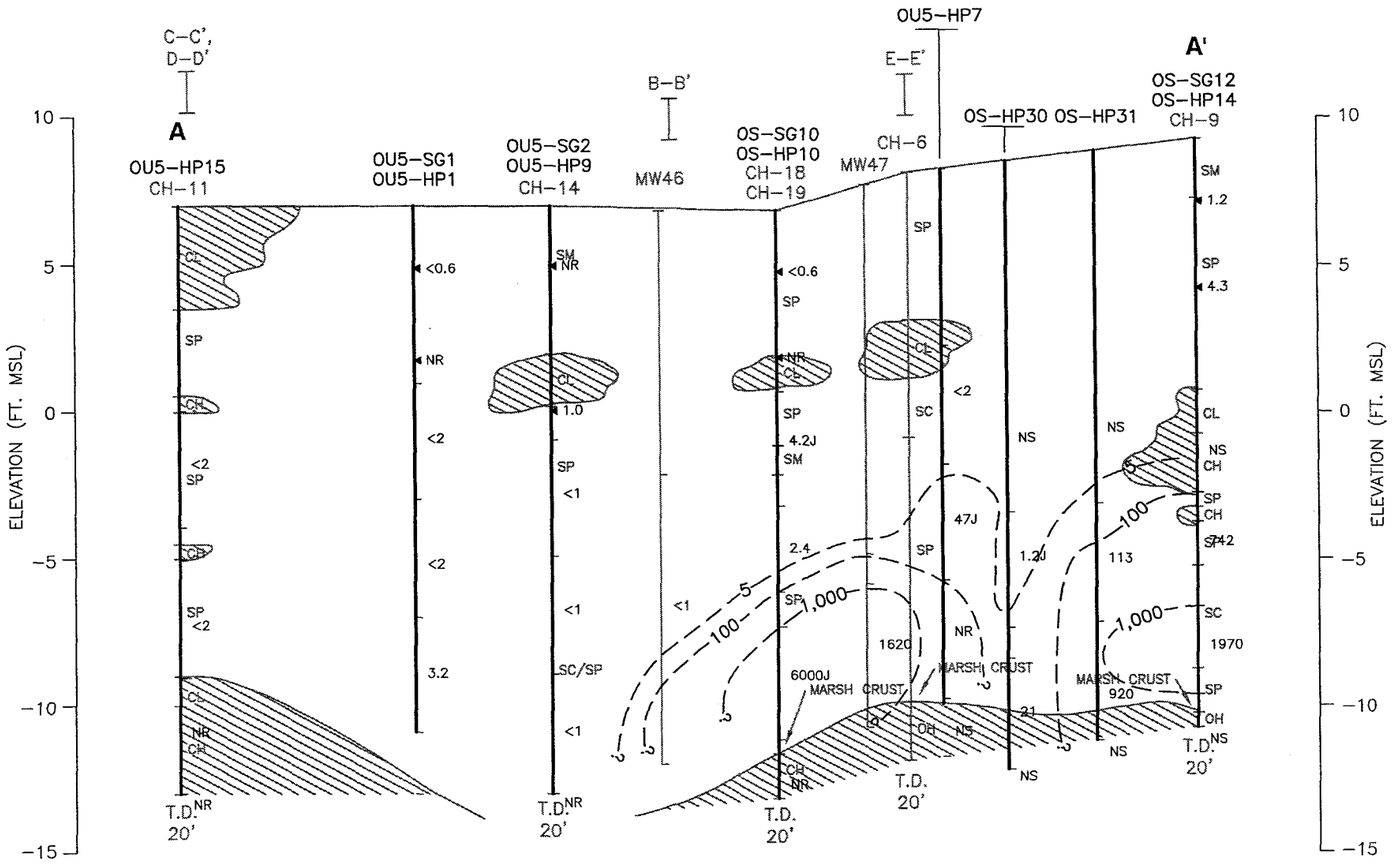
ND denotes not detected above minimum detection limit

NS denotes no sampled attempted or no recovery

ppbv denotes parts per billion volume

J denotes estimated value

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	AL41BASE	CONCORD	BJ 12-2-02	12/5/02	JES 12/5/02	819814-B82



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATIONS PER BILLION–VAPOR
- ├┤ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS *INTERVAL NOT SAMPLED*
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES.

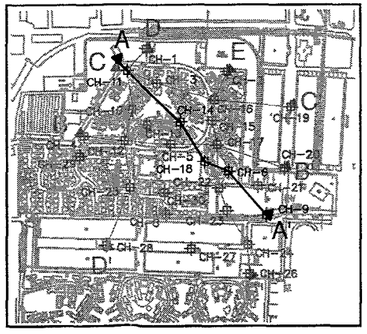
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

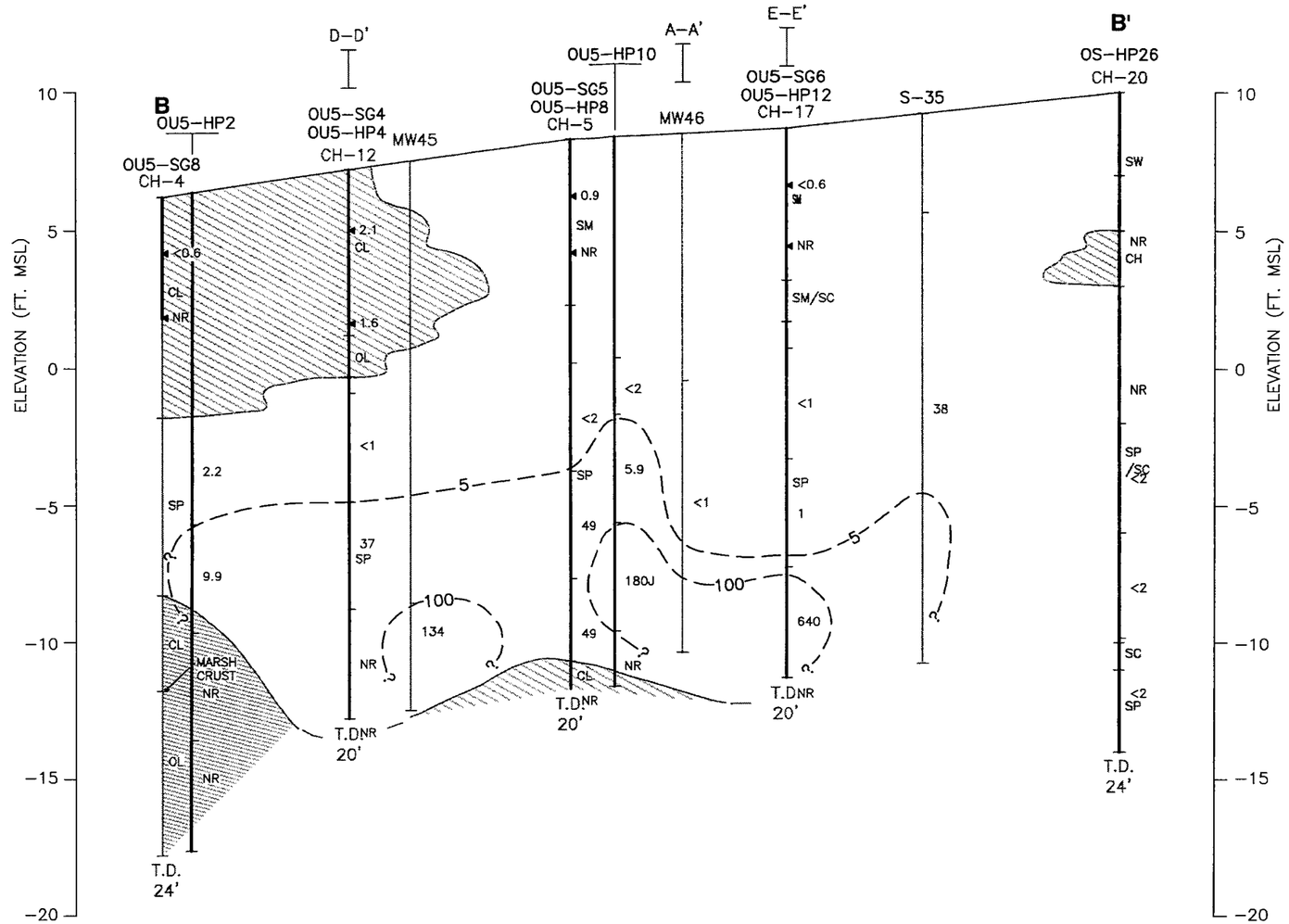
(VERTICAL EXAGGERATION = 60x)

ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–70

BENZENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION A–A'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-2-02	BW 12/5/02	JES 12/5/02	819814-B83



LEGEND

- ◂ SOIL GAS SAMPLING POINT CONCENTRATIONS PER BILLION–VAPOR
- ⊢ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- ⌒ GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES.

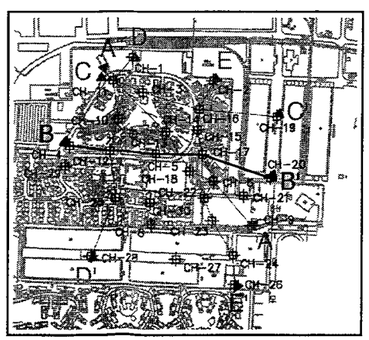
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

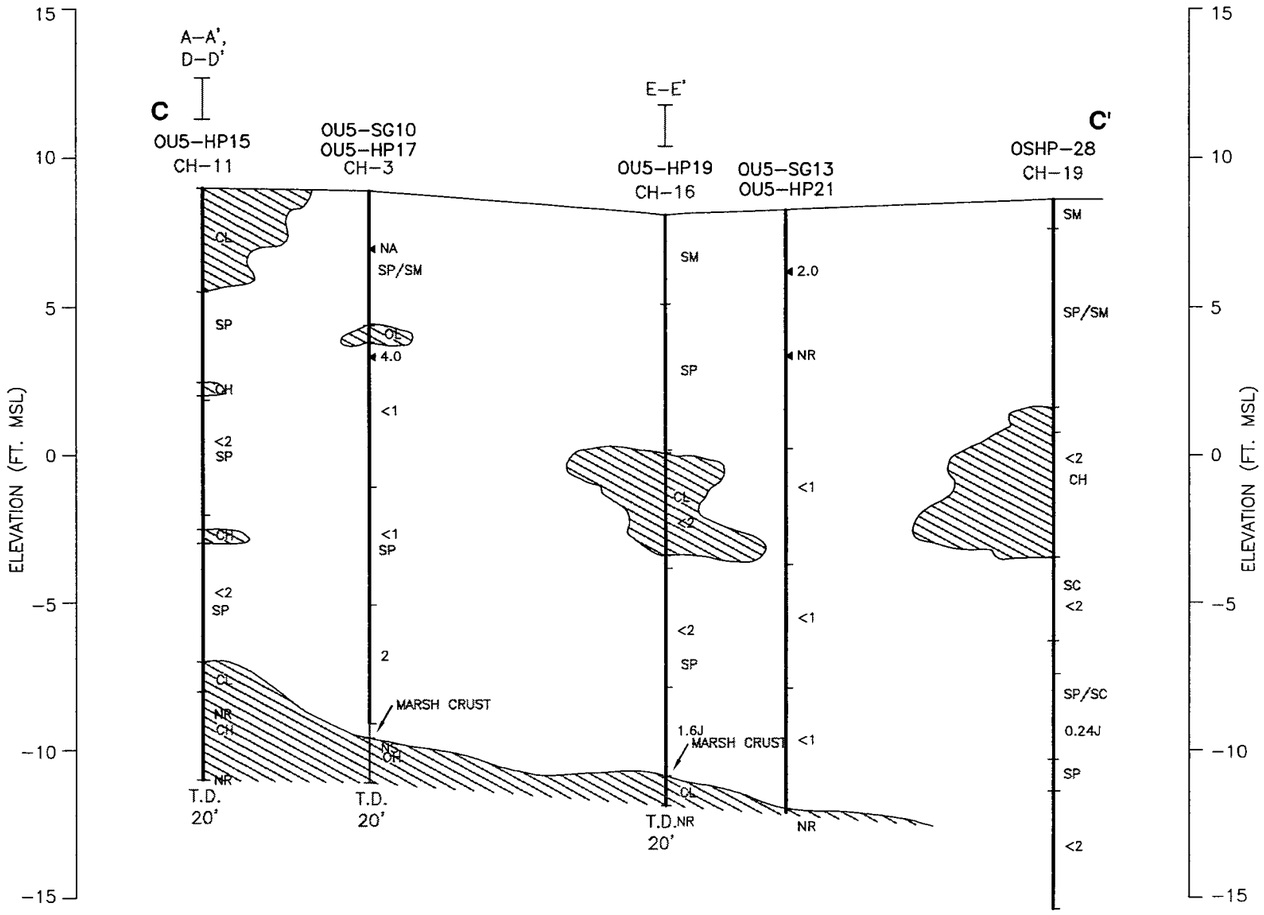
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–71

BENZENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION B–B'

IMAGE	X-REF	OFFICE	DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ	12-2-02	BC	12/5/02	JEB		819814-B84



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATIONS PER BILLION–VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES.

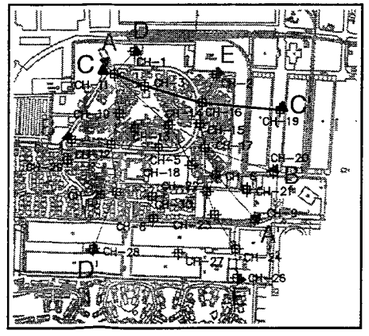
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

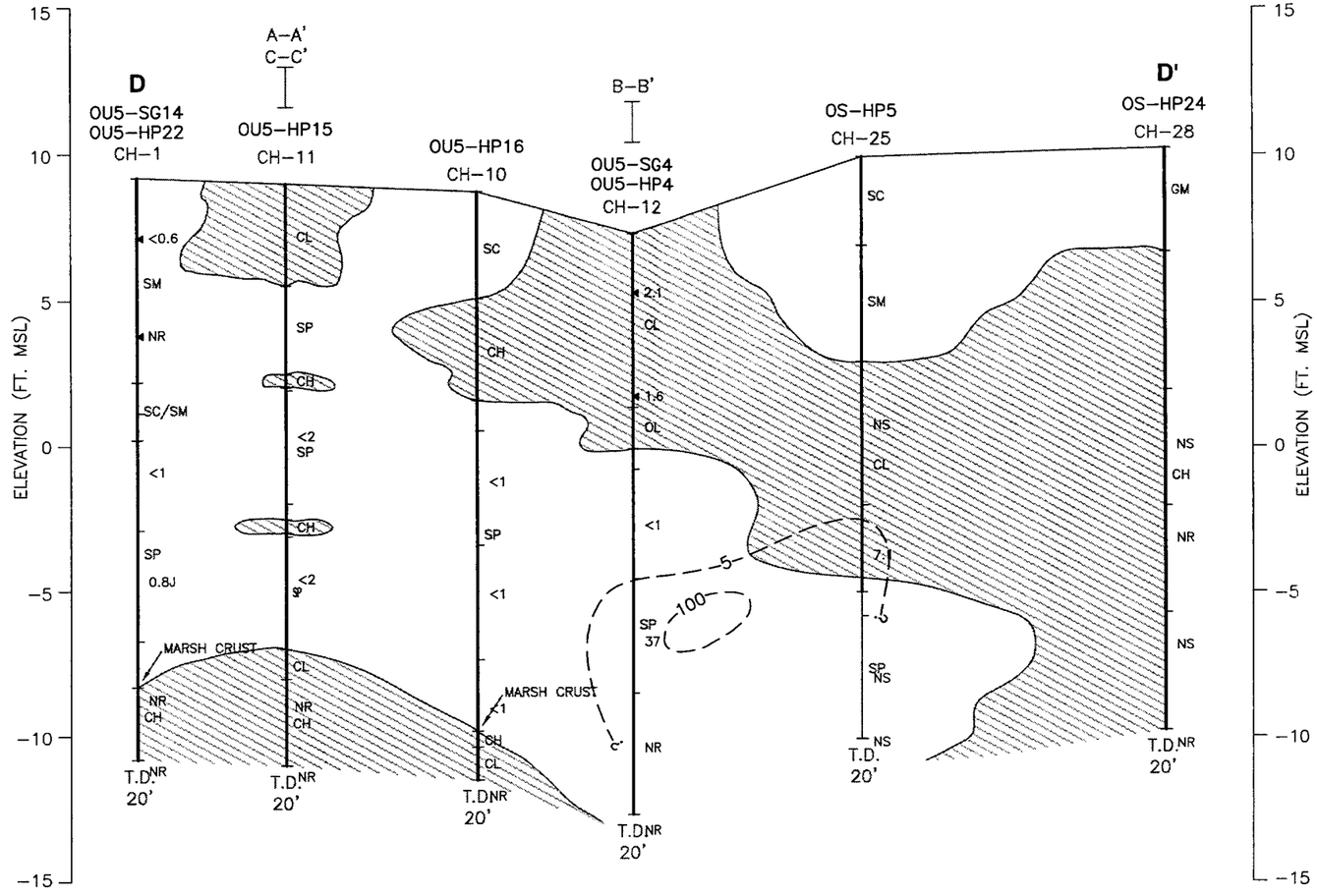
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–72

BENZENE CONCENTRATION IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION C–C'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-2-02	BMR 12/5/02	JES 12/5/02	819814-B85



LEGEND

- ◂ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- ⊢ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES.

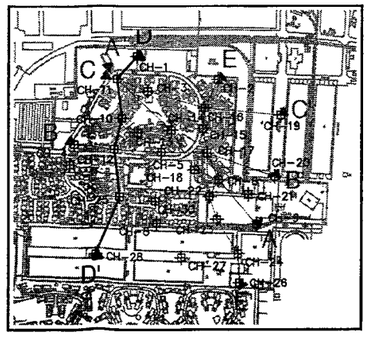
- GM – SILTY GRAVELS, GRAVEL–SAND–SILT MIXTURES
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

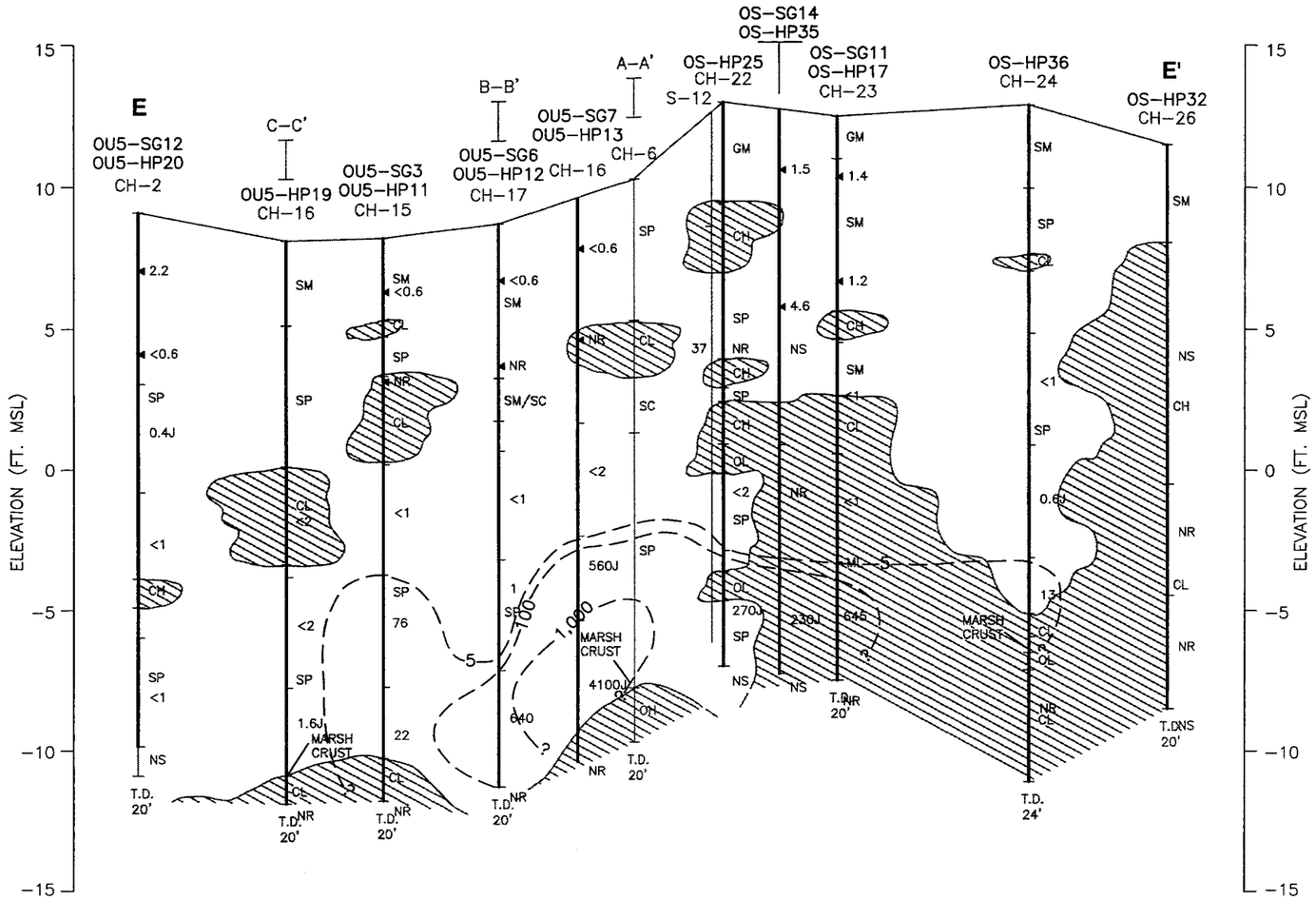
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–73

BENZENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION D–D'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ	12-2-02	JES	819814-B86



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- ├ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

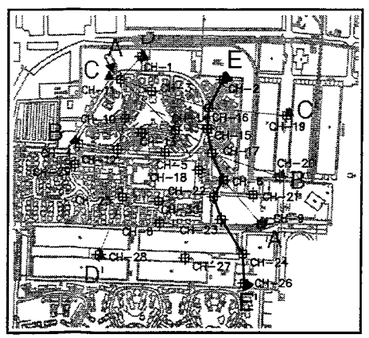
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

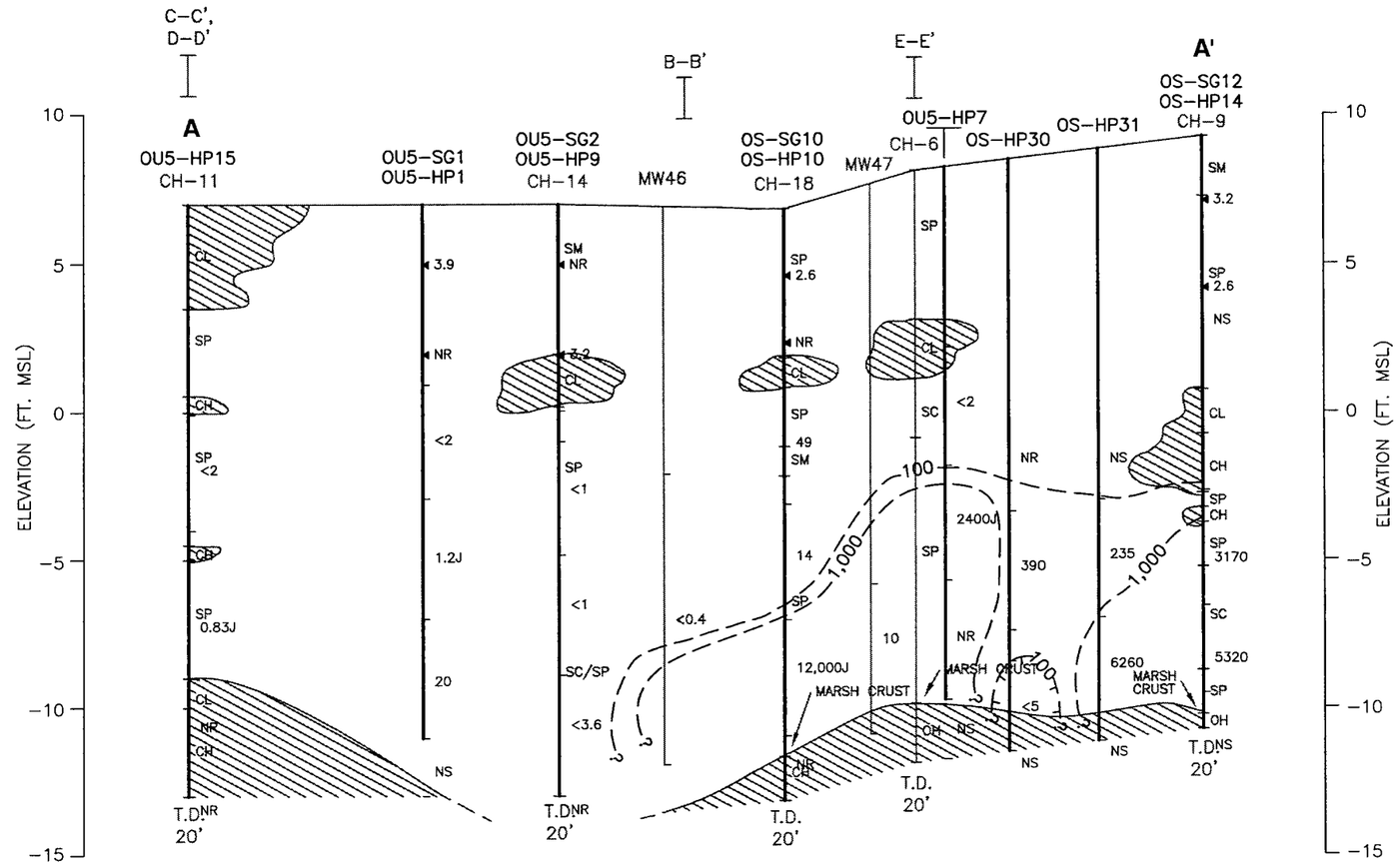
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–74

BENZENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION E–E'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-3-02	RBC 12/5/02	JES 12/6/02	819814-B87



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

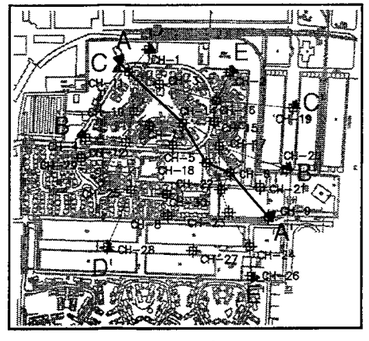
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

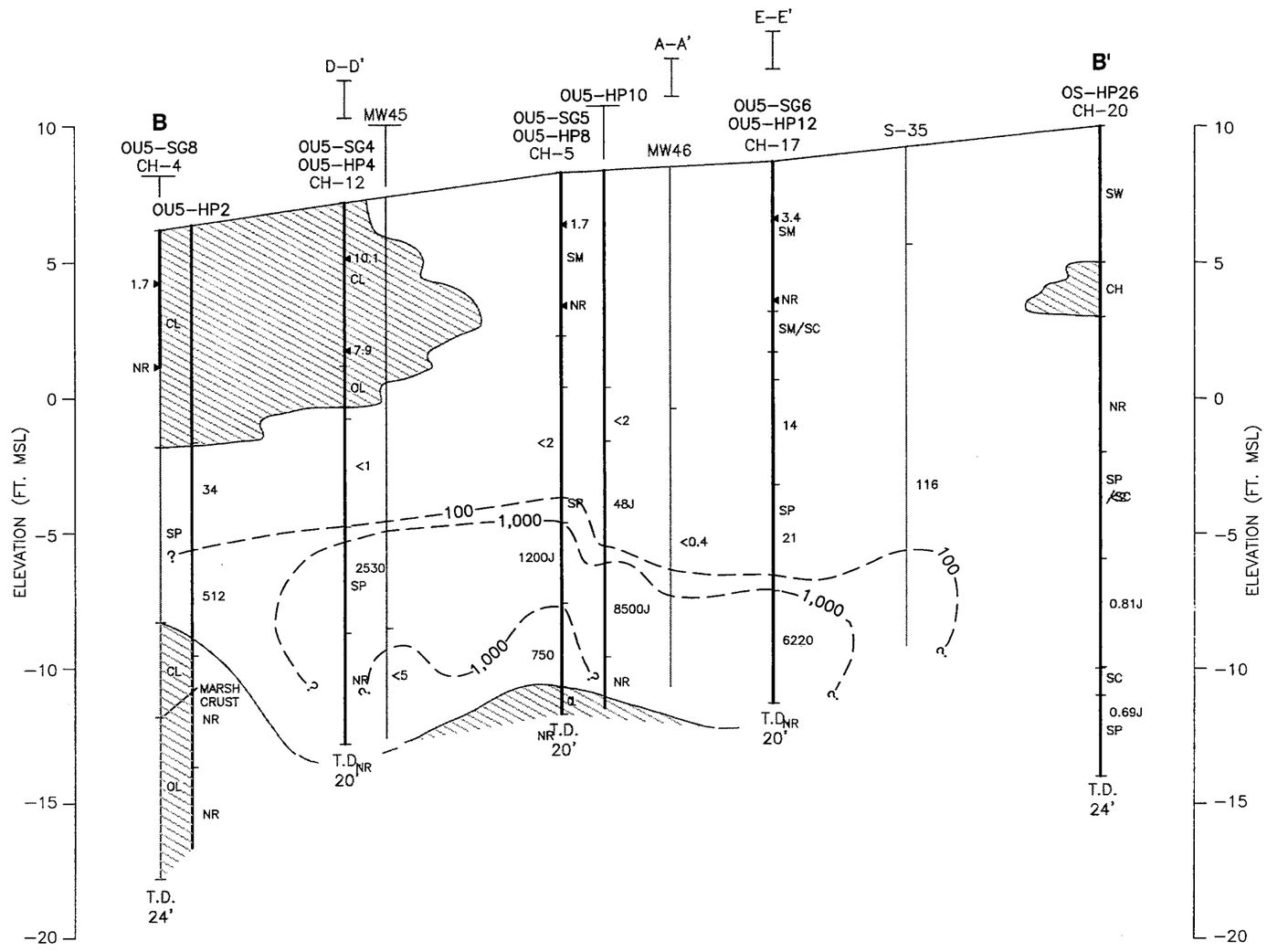
(VERTICAL EXAGGERATION = 60x)

ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–75

NAPHTHALENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION A–A'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-2-02	12/5/02	JES 12/5/02	819814-B88



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

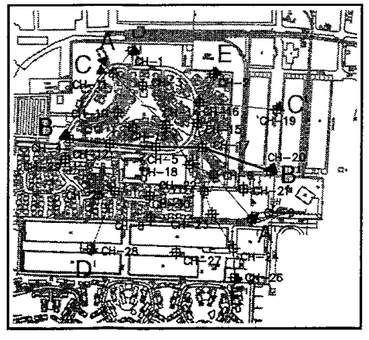
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

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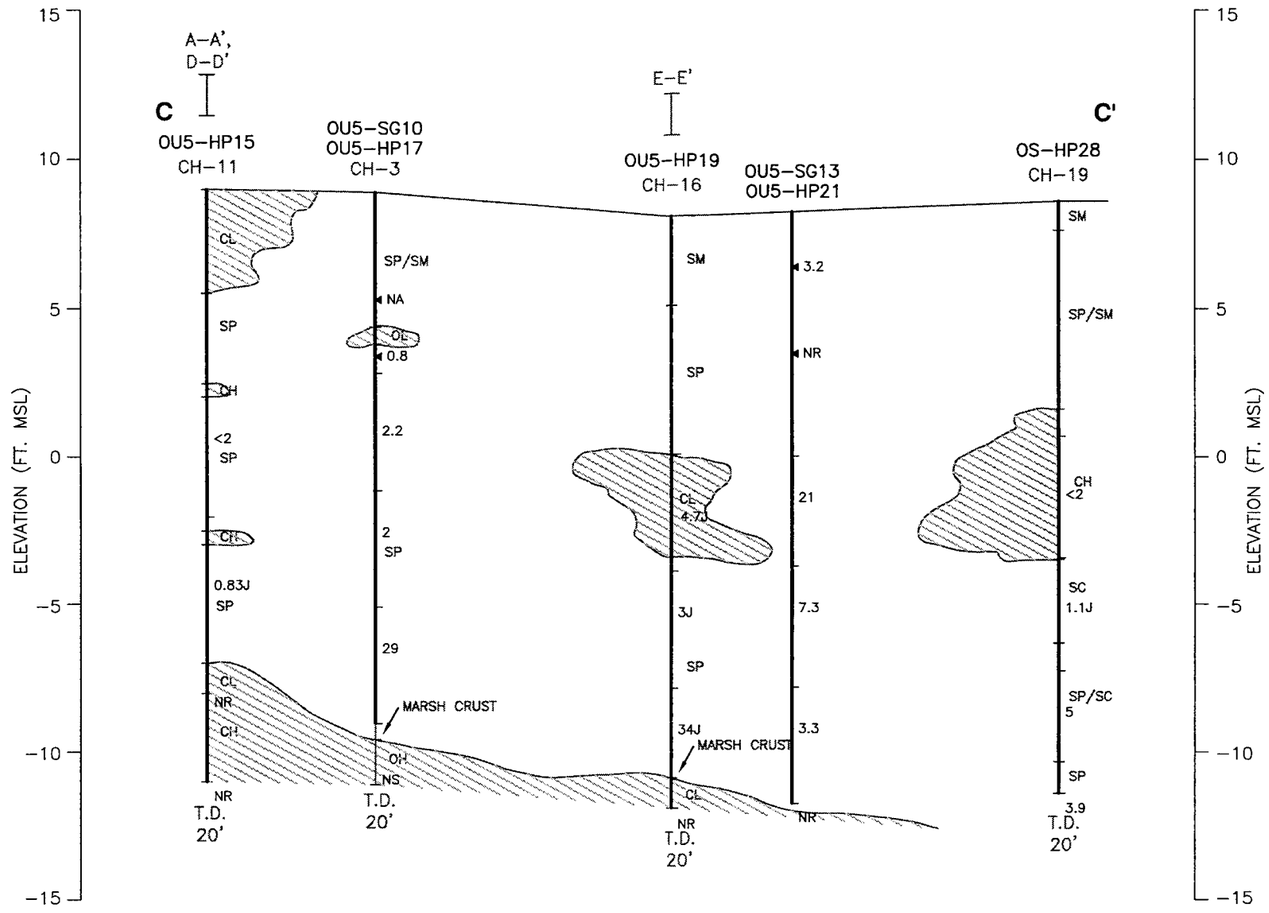
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–76

NAPHTHALENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION B–B'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-2-02	RAC 12/5/02	JES 12/10/02	819814-B89



LEGEND

- ◀ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

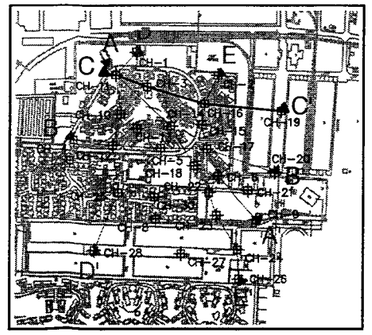
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

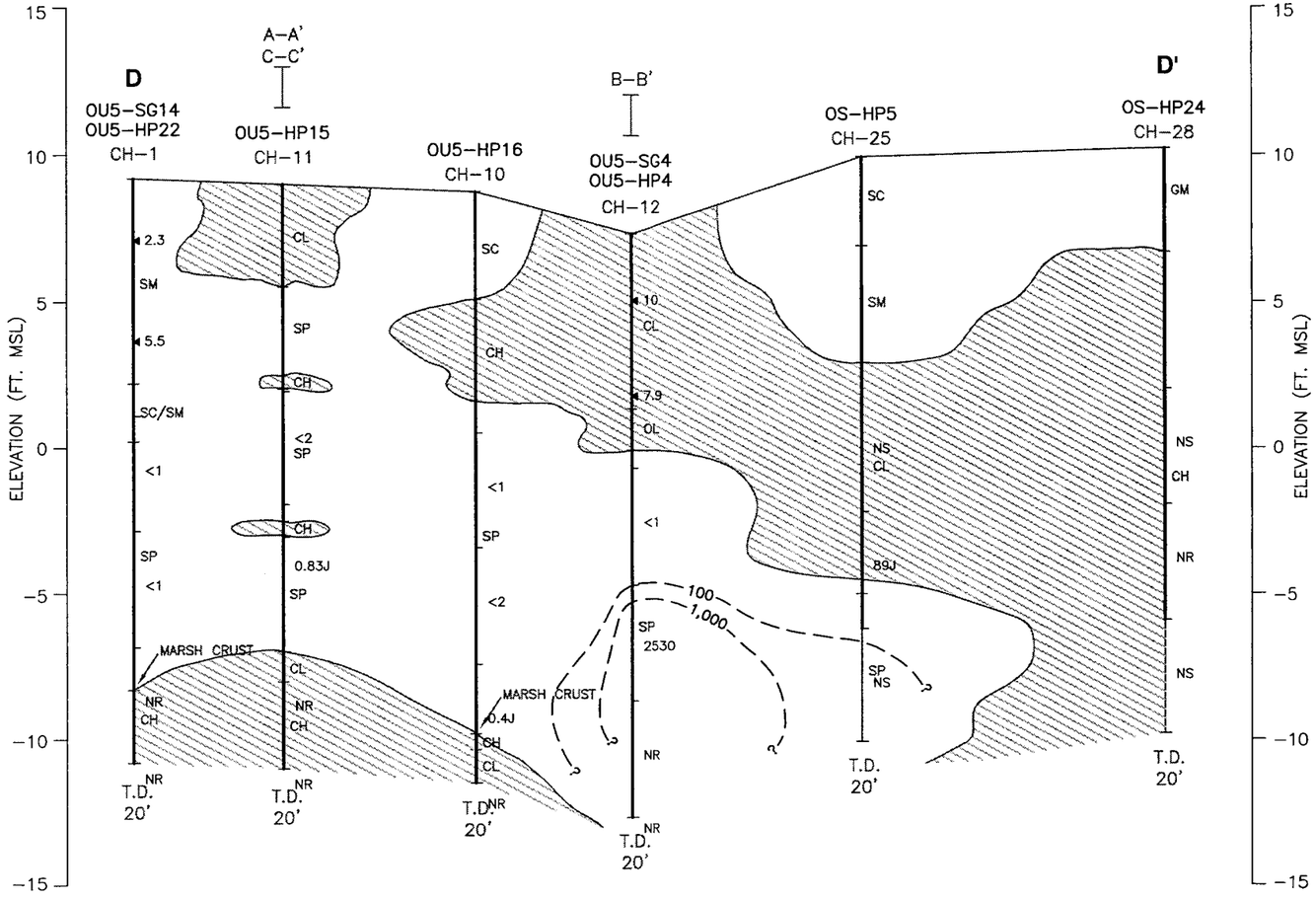
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–77

NAPHTHALENE CONCENTRATION IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION C–C'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-3-02	RBC	JES	819814-B90



LEGEND

- ◂ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

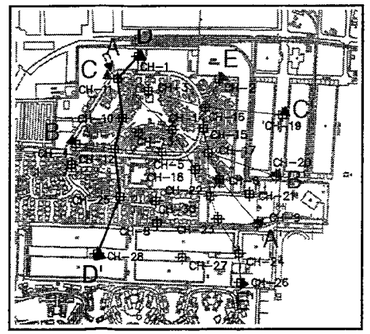
- GM – SILTY GRAVELS, GRAVEL–SAND–SILT MIXTURES
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
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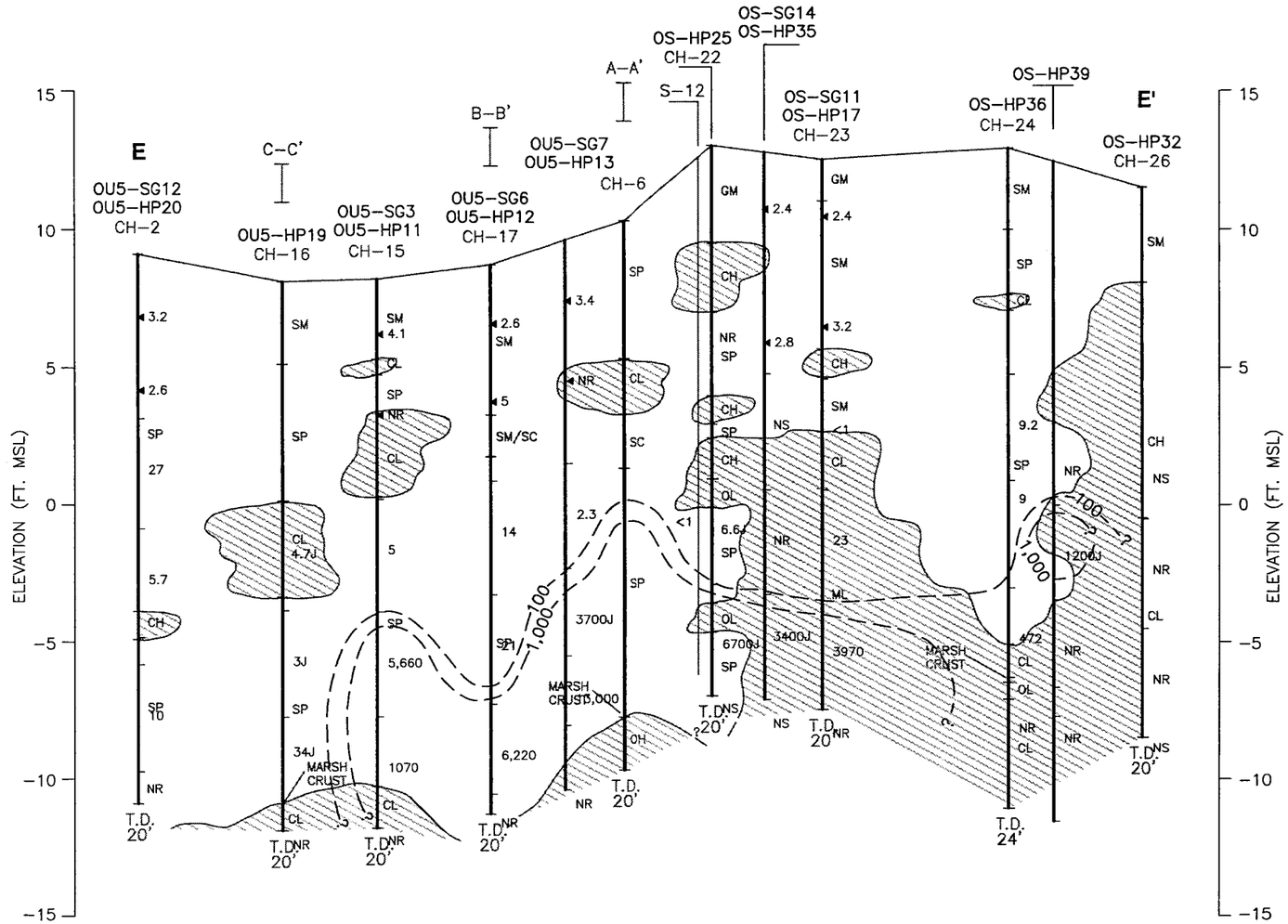
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–78

NAPHTHALENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION D–D'

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-2-02	RAC 12/5/02	JES 12/5/02	819814-B91



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION-VAPOR
- GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED
- GEOLOGIC CONTACT

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

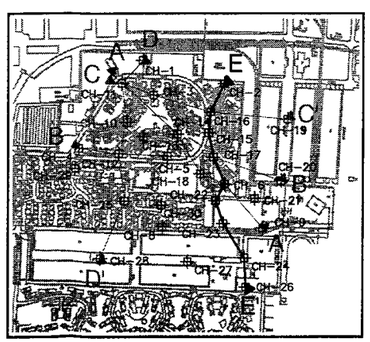
- GM – SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
- GC – CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
- SW – WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND-SILT MIXTURES
- SC – CLAYEY SANDS, SAND-CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

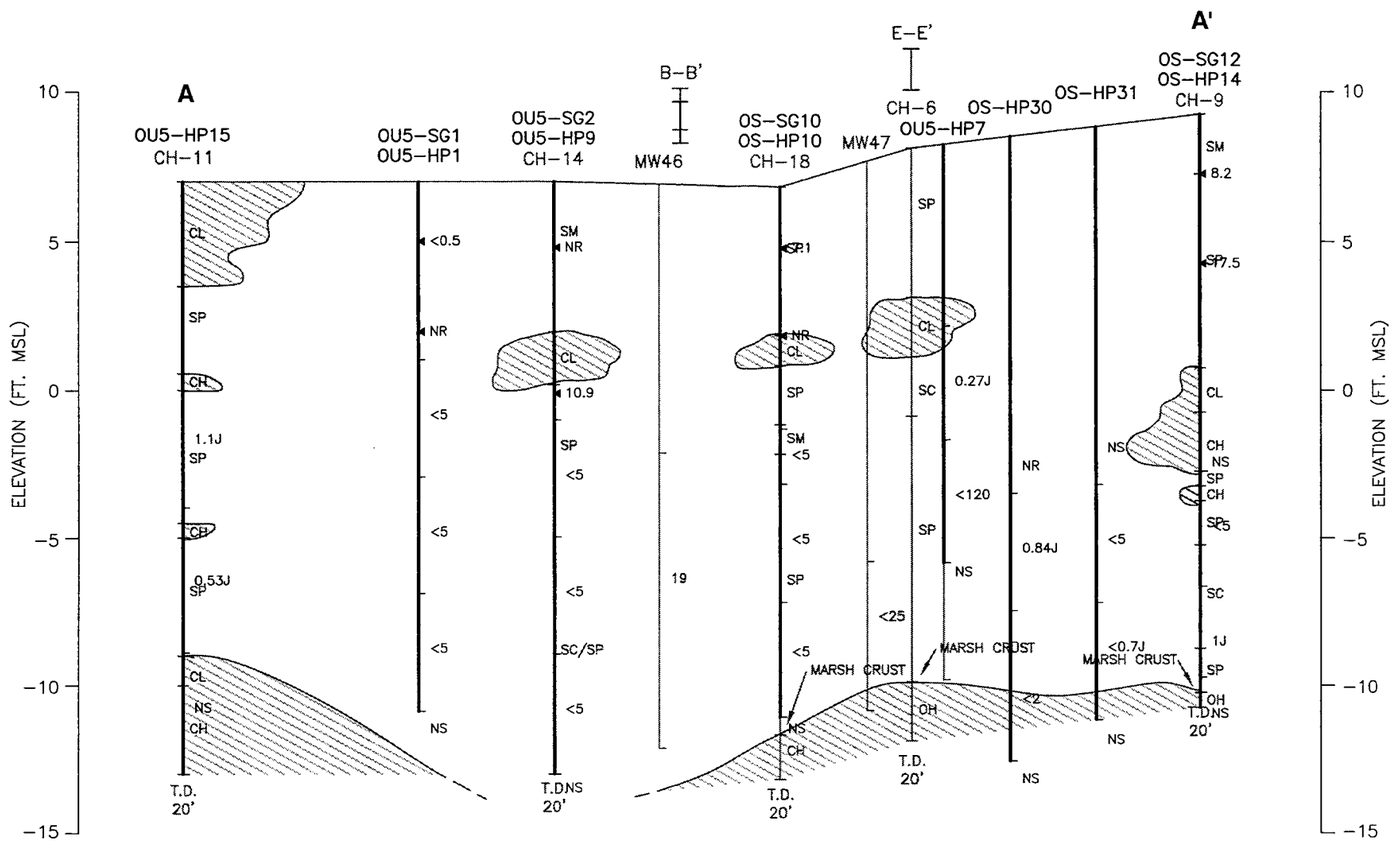
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4-79

NAPHTHALENE CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION E-E'

DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
BJ	12-3-02	12/3/02	JES	12/5/02	819814-B92

IMAGE	X-REF	OFFICE
---	ALA1BASE	CONCORD



LEGEND

◂ SOIL GAS SAMPLING POINT
CONCENTRATION IN PARTS PER BILLION–VAPOR

GROUNDWATER SAMPLE INTERVAL,
CONCENTRATION IN MICROGRAMS PER LITER

NR INSUFFICIENT VOLUME FOR SAMPLE

NS INTERVAL NOT SAMPLED

NA SAMPLE NOT ANALYZED

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES

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SC – CLAYEY SANDS, SAND–CLAY MIXTURES

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CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS

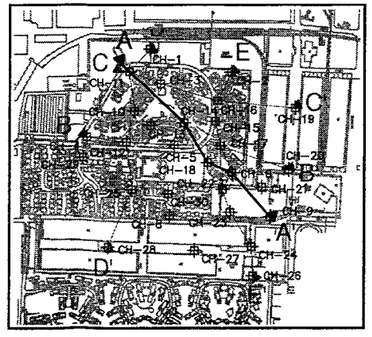
OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

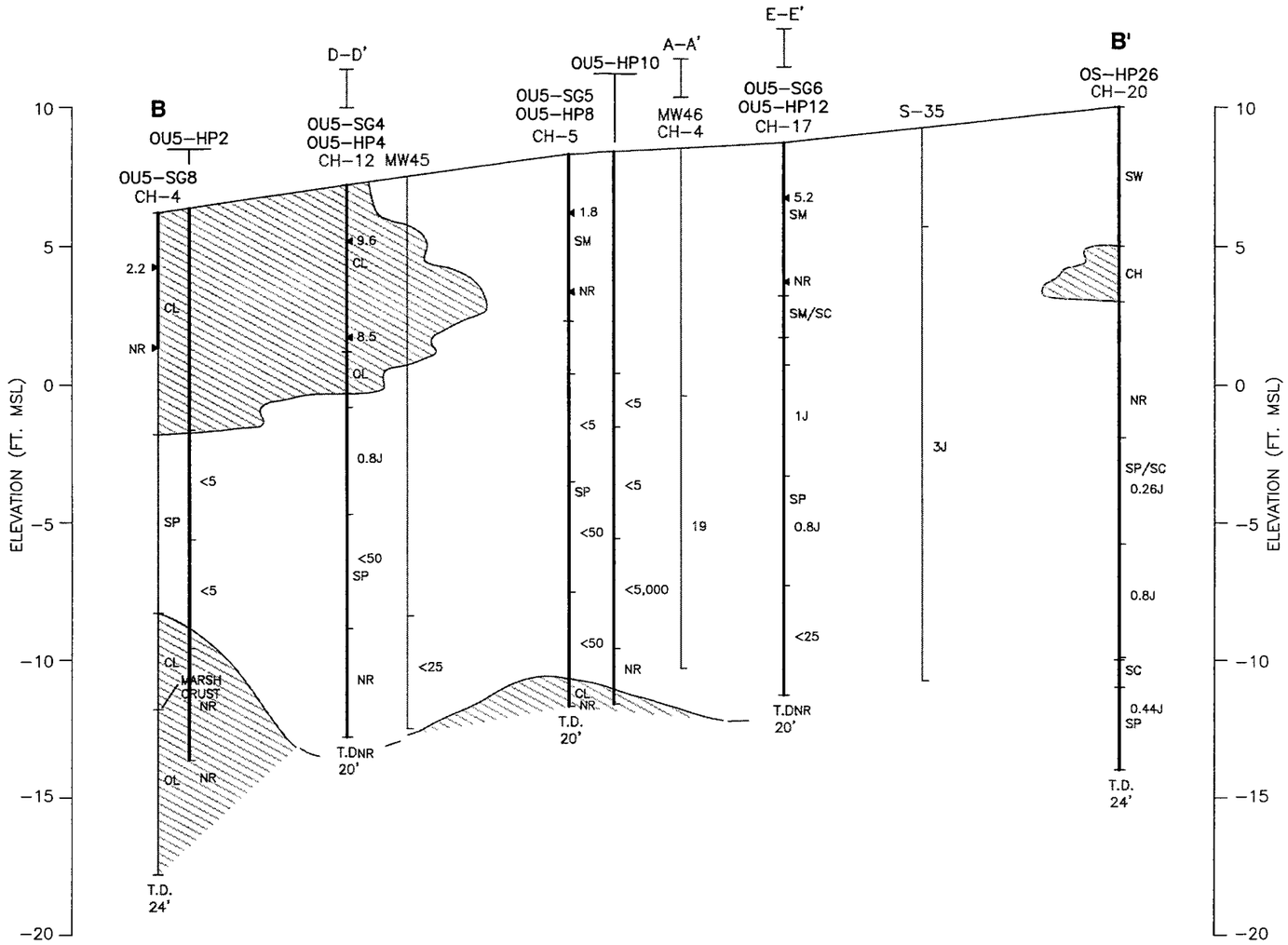
0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–80

METHYL TERTIARY BUTYL ETHER (MTBE) CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION A–A'



LEGEND

◄ SOIL GAS SAMPLING POINT
CONCENTRATION IN PARTS PER BILLION–VAPOR

GROUNDWATER SAMPLE INTERVAL,
CONCENTRATION IN MICROGRAMS PER LITER

NR INSUFFICIENT VOLUME FOR SAMPLE

NS INTERVAL NOT SAMPLED

NA SAMPLE NOT ANALYZED

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES

SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES

SM – SILTY SANDS, SAND–SILT MIXTURES

SC – CLAYEY SANDS, SAND–CLAY MIXTURES

CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS

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CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS

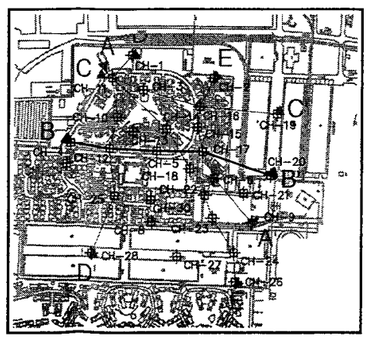
OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE
0 300 600 FEET

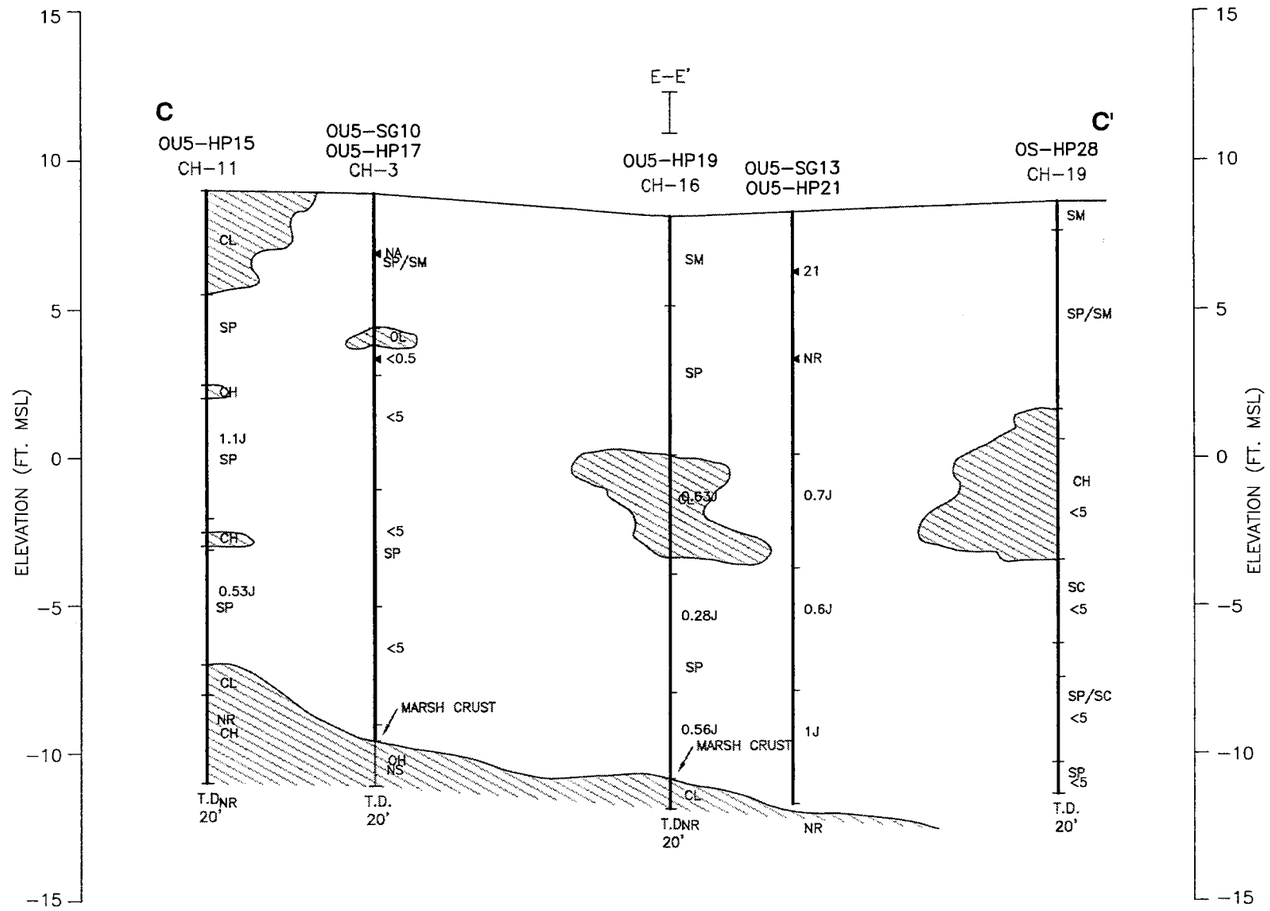
VERTICAL SCALE
0 5 10 FEET
(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–81
METHYL TERTIARY BUTYL ETHER (MTBE) CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION B–B'

IMAGE	X–REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BU 12-3-02	cal 12/3/02	JES 12/6/02	819814–B93

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALA1BASE	CONCORD	BJ 12-3-02	12/5/02	JES 12/5/02	819814-B94



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- ├┤ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

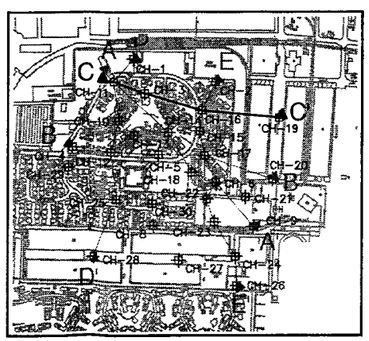
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

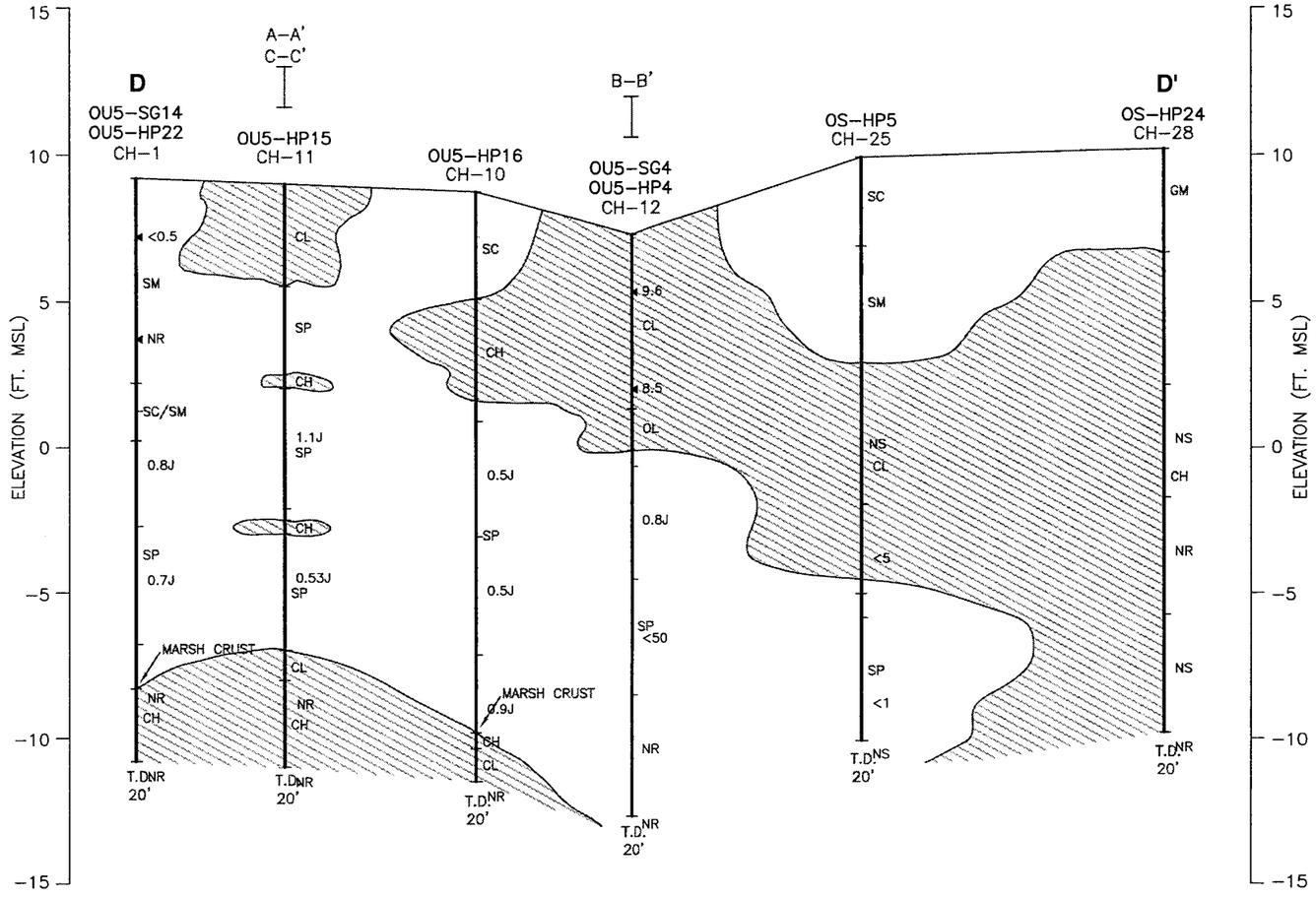
0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–82

METHYL TERTIARY BUTYL ETHER (MTBE) CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION C–C'



LEGEND

- ◂ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- ┤ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

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- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
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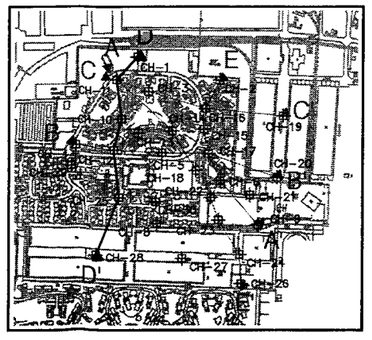
- CL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

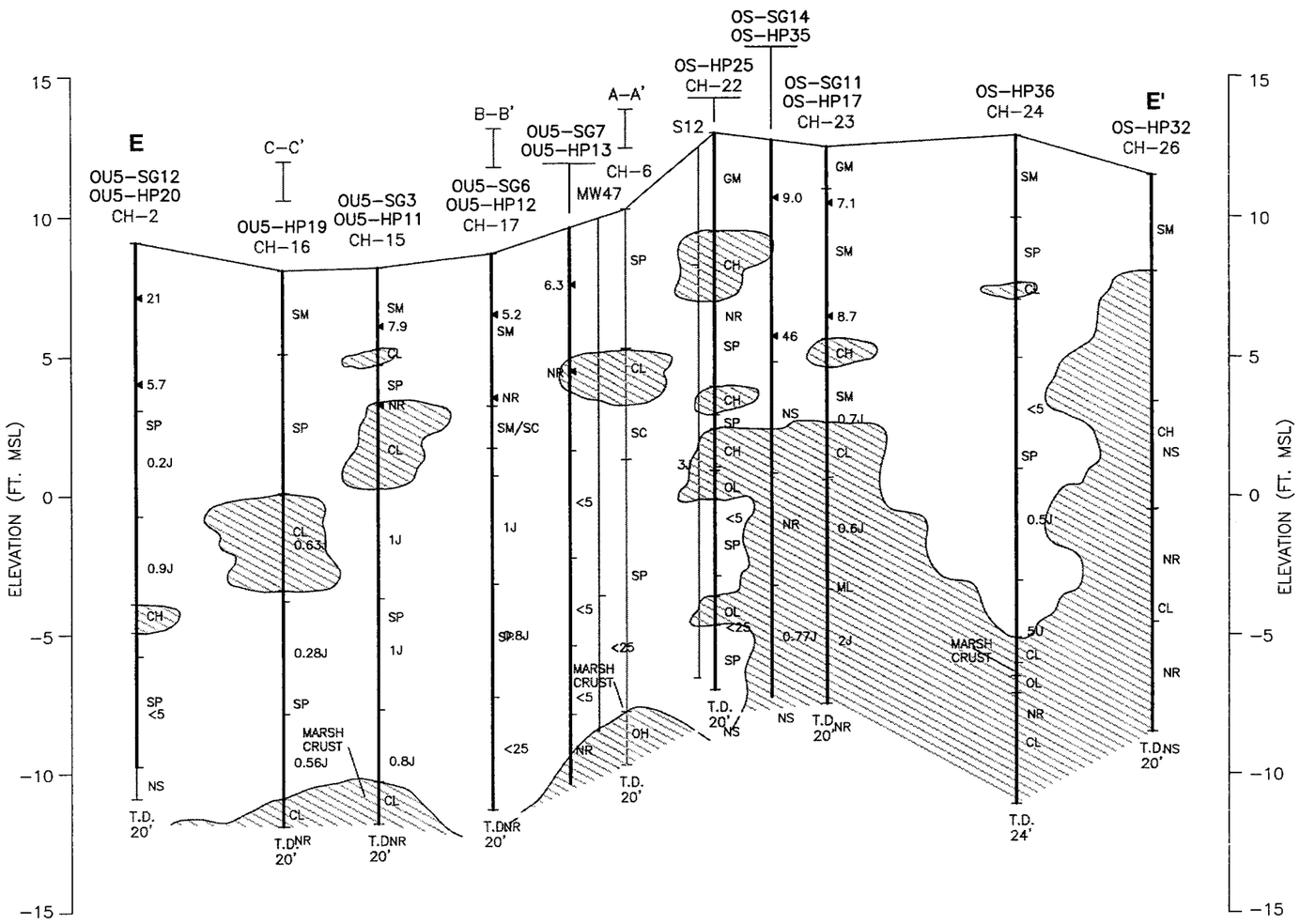
OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–83

METHYL TERTIARY BUTYL ETHER (MTBE) CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION D–D'

IMAGE	X–REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALAIBASE	CONCORD	BU 12-3-02	12/5/02	JES 12/5/02	819814–B95

IMAGE	X-REF	OFFICE	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
---	ALAIBASE	CONCORD	BJ	12-3-02	12/5/02	12/5/02	819814-B96



LEGEND

- ◄ SOIL GAS SAMPLING POINT CONCENTRATION IN PARTS PER BILLION–VAPOR
- ├┤ GROUNDWATER SAMPLE INTERVAL, CONCENTRATION IN MICROGRAMS PER LITER
- NR INSUFFICIENT VOLUME FOR SAMPLE
- NS INTERVAL NOT SAMPLED
- NA SAMPLE NOT ANALYZED

NOTE

1. T.D.s SHOWN ARE FOR COREHOLES

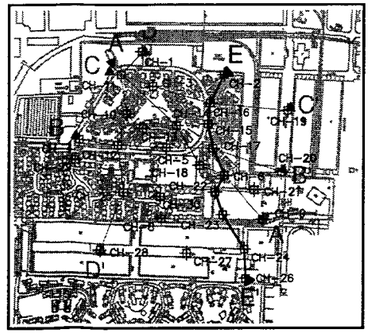
- GM – SILTY GRAVELS, GRAVEL–SAND–SILT MIXTURES
- GC – CLAYEY GRAVELS, GRAVEL–SAND–CLAY MIXTURES
- SW – WELL–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SP – POORLY–GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
- SM – SILTY SANDS, SAND–SILT MIXTURES
- SC – CLAYEY SANDS, SAND–CLAY MIXTURES
- CL – INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
- OL – ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
- CH – INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
- OH – ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS

NOTE

MARSH CRUST NOTED WHEN INDICATED ON BORING LOGS.

SAND OR GRAVEL DOMINATED UNIT

SILT OR CLAY DOMINATED UNIT



INSET

HORIZONTAL SCALE

0 300 600 FEET

VERTICAL SCALE

0 5 10 FEET

(VERTICAL EXAGGERATION = 60x)

OPERABLE UNIT 5
REMEDIAL INVESTIGATION REPORT
ALAMEDA POINT
ALAMEDA, CALIFORNIA

FIGURE 4–84

METHYL TERTIARY BUTYL ETHER (MTBE) CONCENTRATIONS IN GROUNDWATER AND SOIL GAS GEOLOGIC CROSS SECTION E–E'

concentrations were converted from micrograms per cubic meter ($\mu g/m^3$) to parts per billion volume (ppbv). This allows for direct comparison with groundwater concentrations that are in µg/L (parts per billion). The conversion was completed by the following calculation:

$$Concentration\ (ppbv) = [Concentration\ (\mu g/m^3) \times D]/MW$$

Where:

D is 24.055 which is the constant for the volume of vapor at standard pressure and temperature
MW is the molecular weight of the compound

Benzene concentrations were low, with a maximum detection of 6.2 ppbv (20 $\mu g/m^3$) in the shallow (2 feet bgs) sample at OS-SG1 (see Figure 4-66) and 4.6 ppbv (15 $\mu g/m^3$) at the deeper (5 feet bgs) sample at OS-SG14 (see Figure 4-67). Naphthalene maximum reported concentrations were 10.1 ppbv (54 $\mu g/m^3$) at 2 feet bgs from OU5-SG4 (see Figure 4-68) and 33.8 ppbv (180 $\mu g/m^3$) at 5 feet bgs from OS-SG16 (see Figure 4-69). Methyl tertiary butyl ether maximum reported concentrations were 20.5 ppbv (34 $\mu g/m^3$) at 2 feet bgs from OU5-SG13 and 46.4 ppbv (170 $\mu g/m^3$) at 5 feet bgs from OS-SG14.

Other VOCs reported in one or more soil gas samples include:

- 1,1,1-trichloroethane
- 1,1-dichloroethane
- 1,1-dichloroethene
- 2-butanone
- 2-hexanone
- 4-methyl-2-pentanone
- Acetone
- Chlorobenzene
- Chloroethane
- Chloroform
- Cis-1,2-dichloroethene
- Ethylbenzene
- Xylenes
- Styrene
- Tetrachloroethene
- Toluene
- Trichloroethene
- Vinyl acetate

Complete soil gas analytical results are provided in Appendix D.

The above chemicals that were detected in one or more samples in both soil gas and groundwater include 1,1-dichloroethene, 2-butanone, chlorobenzene, chloroform, cis-1,2-dichloroethene, ethylbenzene, methylene chloride, MTBE, styrene, toluene, tetrachloroethene, and xylenes. The other compounds were not detected in groundwater samples from this study. The occurrence of MTBE appears to be widespread in soil gas. Concentration ranges from a minimum concentration of 6.6 $\mu g/m^3$ in soil gas sample location OU5-SG05 (2 feet bgs) to a maximum of 170 $\mu g/m^3$ at OS-SG14 (5 feet bgs). Although MTBE was also found in groundwater, the occurrence in soil gas is much more prevalent.

These soil gas results suggest that there is little volatilization of benzene and other VOCs in groundwater to the soil. This may be due to several factors. First, VOC concentrations in groundwater samples collected from the intermediate depth interval (16 to 20 feet bgs) decrease upward to the water table. Since significantly lower VOC concentrations are found in the shallower intervals (above 12 feet bgs), there is very little quantity of chemical available to volatilize into soil gas and therefore high soil gas concentrations would not be expected. Second, some of the soils within the upper groundwater interval are typically fine to very fine-grained, containing silts and clays. These fine-grained soils are likely to impede the movement of vapors within the vadose zone. Finally, many of the deeper soil samples had moderate to high soil moisture content, which also inhibits the upward movement of soil vapor by decreasing the air-filled porosity of the soil. This is supported by the lower success rates in obtaining soil gas samples from deeper intervals. Only approximately one-third of the sampling attempts from the 5-foot sampling interval were successful compared to all but one at the 2-foot interval. Observations in the field indicate that water found in the 5 to 7 foot sample interval was the primary cause for failure to collect a soil gas sample.

4.5 Geotechnical Testing

Geotechnical testing was completed on 18 samples collected from nine coreholes. The testing was completed to provide information on physical characteristics of the OU, and can be used to aid in estimating contaminant transport and/or exposure pathways. Samples were tested for grain size distribution, soil classification, moisture content, hydraulic conductivity, and total organic carbon. Table 4-14, "Summary of Geotechnical Testing Results" summarizes the geotechnical testing results.

The data show some general relationships between soil type. Silts and clays tended to generally have higher moisture content, lower density, lower hydraulic conductivity, and high total organic

Table 4-14
Summary of Geotechnical Testing Results

Sample Location	Sample Depth (feet bgs)	Sample Number	Sample Collection Date	Grain Size Distribution (ASTM D2487)	Moisture Content (ASTM D2216) (percent)	Dry Density (ASTM D4564) (pcf)	Hydraulic Conductivity (ASTM D5084) (cm/sec)	Total Organic Carbon (mg/kg)
CH-01	2	181-0795	05/30/2001	Lean clay w/ sand	20.3	NM	NM	16,800
CH-01	7	181-0796	05/30/2001	Silty sand	21.0	100.83	4.1E-06	19,400
CH-02	2	181-0797	05/30/2001	Silty sand w/ gravel	10.1	126.07	3.5E-05	110 U
CH-02	7	181-0798	05/30/2001	Poorly-graded sand w/ silt	17.9	103.51	1.6E-04	110 U
CH-03	2	181-0799	05/30/2001	Poorly-graded sand w/ silt	5.6	106.71	7.7E-04	3,860
CH-03	7	181-0800	05/30/2001	Poorly-graded sand	15.1	110.10	1.0E-03	110 U
CH-04	2	181-0805	06/07/2001	Sandy lean clay	14.9	86.09	1.2E-04	15,700
CH-04	7	181-0806	06/07/2001	Silt	68.9	58.58	1.4E-07	11,100
CH-05	2	181-0801	05/30/2001	Silty sand	15.2	104.75	2.7E-04	6,390
CH-05	7	181-0802	05/30/2001	Poorly-graded sand	13.2	NM	NM	110 U
CH-06	2	181-0803	05/30/2001	Poorly-graded sand w/ silt	3.7	106.28	3.3E-03	1,400
CH-06	7	181-0804	05/30/2001	Sandy silt	51.8	69.46	1.1E-07	14,500
CH-08	2	178-0035	06/07/2001	Clayey gravel w/ sand	8.4	115.74	1.6E-03	3,670
CH-08	7	178-0036	06/07/2001	Sandy lean clay	34.8	67.22	3.7E-07	3,580
CH-09	2	176-0031	06/04/2001	Poorly-graded sand	3.2	103.70	2.1E-03	110 U
CH-09	7	176-0032	06/04/2001	Poorly-graded sand w/ silt	6.3	93.11	2.3E-03	110 U
CH-10	2	181-0807	06/07/2001	Sandy silt	18.7	108.00	6.1E-08	1,900
CH-10	7	181-0808	06/07/2001	Silt	83.4	48.97	1.1E-07	3,440

bgs denotes below ground surface *ASTM denotes American Society for Testing and Materials* *NM denotes not measured*
pcf denotes pound per cubic foot *cm/sec denotes centimeters per second* *mg/kg denotes milligram(s) per kilogram*

carbon content than the coarser grained sediments containing sand and gravel. Additionally, samples collected from 2 feet bgs, generally had lower moisture content than deeper samples from the same corehole.

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5.0 Baseline Risk Assessment

This section presents the results of the human health risk assessment conducted for Parcel 181 of Operable Unit (OU) 5. The risk assessment assumes that no further remediation has been conducted at Parcel 181 since the remedial investigation (RI) field activities conducted in 2001, although the potential impacts on human health from the recent time-critical removal action (TCRA) is addressed. A preliminary evaluation of the data has also been conducted for soil, groundwater, and soil gas samples at the adjacent properties (Parcels 172 through 176, 178 through 180, and 184), and at the Alameda Annex.

As discussed in Section 2.2.3, a screening level ecological risk assessment was previously conducted for OU-2, which includes OU-5. The results of this screening assessment showed that soils in OU-5 did not pose an unacceptable risk to ecological receptors. Ecologically intensive land-use options, such as use of OU-5 as a wildlife refuge, were not evaluated in that risk assessment. If in the future this should be considered, further ecological risk evaluation would be recommended at that time.

5.1 Purpose and Objectives

A human health risk assessment is an estimate of the potential for adverse health effects to occur as a result of exposure to site-related chemicals. The purpose of this assessment is to determine what risks to human health, if any, are associated with current and future land uses for Parcel 181. The results of the risk assessment will be used to identify any areas of concern at the site and to support the development of remedial action objectives, if necessary.

5.2 Overview of Risk Assessment Process

According to the U.S. Environmental Protection Agency (EPA) (1989) there are four basic steps in the quantitative human health risk assessment process: (1) data collection and analysis; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. These steps are summarized briefly below.

- **Data Collection and Analysis**
  - This process involves gathering and analyzing site-specific data relevant to the human health evaluation. For this risk assessment the main activities were as follows: (1) evaluate the data collected as part of the RI; and (2) select the media and chemicals to be addressed by the quantitative health risk assessment.

- **Exposure Assessment**
  - The exposure assessment estimates the magnitude of the actual or potential human exposures, the frequency and duration of these exposures, and the pathways by which humans are potentially exposed to site-related chemicals. The results of the exposure assessment are pathway-specific and receptor-specific estimates of intakes.

- **Toxicity Assessment**
  - The toxicity assessment examines the potential for site-related chemicals to cause adverse health effects in exposed individuals. It also presents the relationship between the magnitude of exposure and potential adverse effects (dose-response assessment). As part of the toxicity assessment, toxicity values are identified and are then used to estimate the likelihood of adverse effects occurring in humans at different exposure levels.

- **Risk Characterization**
  - Risk characterization is a two-phase process that combines and analyzes results of the exposure assessment and toxicity assessment in order to characterize the potential for adverse health effects to occur as a result of site-specific exposures. In the first phase, the estimated chemical exposure levels are used with exposure assumptions and toxicity information for each chemical to determine cancer risks or noncancer health effects. Evaluation of uncertainties associated with each of the four steps described here is the second phase of risk characterization.

The following EPA and California Environmental Protection Agency (CalEPA) risk assessment guidance documents have been considered in the preparation of this risk assessment:

- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)* (EPA, 1989)
- *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)* (EPA, 1991a)
- *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"* (EPA, 1991b)
- *Exposure Factors Handbook* (EPA, 1997a)
- *Supplemental Guidance to RAGS: Calculating the Concentration Term* (EPA, 1992)
- *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA, 1992)
- *Preliminary Endangerment Assessment Guidance Manual (PEA)* (CalEPA, 1994)

Based on current Navy policy, this risk assessment is being "dual tracked." This means that risks have been calculated separately using both EPA and CalEPA risk assessment methodology. Areas where the federal and state methodologies differ are noted throughout this section.

5.3 Organization of the Risk Assessment

This risk assessment is divided into seven sections as follows:

- **Sections 5.1 to 5.3 – Purpose and Objectives (5.1), Overview of Risk Assessment Process (5.2), and Organization of Risk Assessment Process (5.3):** describes the purpose and scope of the risk assessment, provides an overview of the risk assessment process, and outlines the section organization.
- **Section 5.4 – Data Collection and Analysis:** identifies the chemicals detected in soil, groundwater, and soil gas to be quantitatively evaluated in the risk assessment.
- **Section 5.5 – Exposure Assessment:** presents the conceptual site model (CSM), which identifies the human populations that may potentially be exposed to site-related chemicals and the pathways through which the exposures may occur. In addition, this section describes the methodology and assumptions used to estimate human intakes.
- **Section 5.6 – Fate and Transport Modeling:** discusses the models used to evaluate the fate and transport of chemicals among environmental media.
- **Section 5.7 – Exposure Point Concentrations:** includes the calculations of chemical concentrations in each environmental media to which people may be exposed in each exposure scenario.
- **Section 5.8 – Toxicity Assessment:** describes the potential health effects and identifies the toxicity values for the chemicals evaluated in this assessment.
- **Section 5.9 – Risk Characterization:** presents the estimated cancer risks and noncancer hazard indices (HI) and a discussion of the uncertainties inherent in the calculation of these values.

Data preparation, analysis, and calculation of exposure point concentrations (EPC) is presented in Appendix B. Risk assessment calculation spreadsheets are contained in Appendix C. Conclusions and remedial action objectives based on this risk assessment are presented in Section 6.0.

5.4 Data Collection and Analysis

The following subsections discuss data evaluation and chemicals of potential concern (COPC).

5.4.1 Data Evaluation Summary

Benzo(a)pyrene (BaP)-equivalent concentrations were calculated for each soil sample by normalizing the concentration of each carcinogenic polynuclear aromatic hydrocarbon (PAH) to the carcinogenicity of BaP, for which both EPA and CalEPA have published separate cancer slope factor (CSF). These calculations were conducted using EPA and CalEPA toxicity equivalency factors, which relate the oral carcinogenicity of these PAHs to that of BaP.

If one or more of the seven PAHs were not detected in a sample, its soil concentration was set equal to one half the sample-specific reporting limit. Weighted averages of soil analytical data with depth (e.g., 0 to 4 feet and 0 to 8 feet) were calculated as the weighted mean of the original samples (i.e., 0 to 0.5 feet, 0.5 to 2 feet, 2 to 4 feet, and 4 to 8 feet). The weighted averages were used to calculate EPCs for the risk assessment, as discussed in Section 5.5. Additional information on the calculation of BaP-equivalent concentrations, weighted averages, and EPCs for the risk assessment is provided in Appendix B.

As discussed in Section 4.0, BaP-equivalent soil concentrations from 0 to 4 foot depths are higher in the northern and western areas encompassed by Mosley and Singleton Avenues, with lower concentrations in the eastern portion of Parcel 181. Benzo(a)pyrene-equivalent soil concentrations also generally increase with depths between 0 and 8 feet in the northern and western regions of Parcel 181. By contrast, metal soil concentrations in Parcel 181 reveal slight patterns over area and depth that do not correspond to the PAH pattern. This suggests that the human activities responsible for the distribution of PAHs in site soils have not affected the soil concentrations of metals.

An evaluation of risk due to exposure from PAHs in soils requires an understanding of what concentrations are present in soil and how the concentration varies across OU-5. Since concentrations vary significantly across the site, not all parts of OU-5 may pose the same risk. To prevent under- or over-estimating risk across the site, further evaluation of soil BaP-equivalent concentrations was performed to define decision areas.

Decision areas correspond to portions of OU-5 where the concentration of the main risk drivers are relatively similar, as described in Section 3.4, and according to the approach described in Section 7.1 of the RI Work Plan (Neptune and Company, 2001). These evaluations employed visual reviews of spatial plots supported by statistical comparisons of the data to identify areas of relative homogeneity to support the calculation of EPCs for BaP-equivalent concentrations. This resulted in defining seven decision areas, where BaP-equivalent concentrations in the top three

depth intervals were relatively homogeneous. These activities are described in detail in Section 5.5 and Appendix B of this RI Report.

As discussed in Section 3.4.1, the number of locations where soil samples were analyzed for BaP-equivalent concentrations is greatest for the 0 to 0.5 foot below ground surface (bgs), 0.5 to 2 foot bgs, and 2 to 4 foot bgs depth intervals. This is because the probability of chronic human exposure to soils decreases as a function of depth. Below 2 feet, it is unlikely that residents would experience any exposure related to landscaping or other such activities, but to be conservative BaP-equivalent data for the top 4 feet were evaluated to define decision areas.

Most groundwater data were obtained from only two depth intervals (12 to 16 feet bgs and 16 to 20 feet bgs) of the four intervals sampled, due to poor recovery of water in the upper (8 to 12 feet bgs) and lower (greater than 20 feet bgs) intervals. The groundwater plume containing volatile organic compounds (VOC) was not bounded to the west and south. Volatile organic compound concentrations were also not bounded at depth, as their concentrations appear to increase in the deeper intervals.

To evaluate the potential for VOCs to migrate from groundwater through soil and into on-site buildings, an evaluation of the soil gas versus groundwater concentrations of VOC was performed. As discussed in Section 4.4, the low concentrations of VOCs detected in soil gas correlated with low groundwater concentrations found in the shallow sample interval. This suggests that there is currently limited potential for VOCs in groundwater to impact ambient or indoor air.

5.4.2 Chemicals of Potential Concern

As discussed in Section 4.0, field activities associated with the remedial investigation took place between May 17, 2001 and June 19, 2001. These activities included collection of soil, groundwater, and soil gas samples throughout Parcel 181 and some of the adjacent parcels. The results of these sampling activities were discussed in detail in Section 4.0, and summaries of the analytical results from each medium are shown in Tables 4-1 through 4-9. Additional soil data were collected in October 2001 to evaluate PAH concentrations in Parcels 179 and 180. These data are not included in the Parcel 181 data set and are assessed separately in the risk characterization (Section 5.9.7). There were no site-specific background samples taken during this investigation.

Soil PAH data collected in OU-5 during previous sampling events were only used in the planning process to support the sampling design of the RI. The principal reason that the

historical PAH soils data were not combined with the RI PAH soils data was that the RI used a different analytical method with lower detection limits.

As summarized in Table 4-1, sixteen PAHs were analyzed for and detected in site soils. All PAHs were detected at a frequency of greater than five percent in all depth intervals. Ten PAHs were detected at a frequency of greater than 90 percent. All detected PAHs were selected as chemicals of potential concern to be evaluated in this risk assessment.

Metals analysis was also performed for soil samples at the same intervals noted for PAHs. As discussed above, an evaluation of the spatial distribution of metals within Parcel 181 did not reveal any evidence of Navy-related contamination but did reveal slight patterns that do not correspond to PAH patterns. As summarized in Table 4-4, all 17 metals in the analytical suite were detected in at least one sample. Seven metals were detected in 100 percent of the soil samples. Silver was detected in less than five percent of the samples at all depth intervals. All detected metals, including silver, were selected as COPCs and have been quantitatively evaluated in this risk assessment.

Benzene, other VOCs, and PAHs were detected in historical groundwater samples from the southeastern portion of OU-5, in adjacent parcels of the Naval Air Station (NAS) Alameda and the Alameda Annex. For the RI, groundwater samples were collected using direct-push sampling methods and from existing monitoring wells.

As discussed in Section 4.0, 61 locations were sampled using direct-push sampling methods during the RI. Of these locations, 24 were within OU-5 (including one sample located on Parcel 182) and 37 were collected from off site properties. Samples were collected at four depths; 0 to 12 feet bgs, 12 to 16 feet bgs, 16 to 20 feet bgs, and greater than 20 feet bgs. All groundwater samples collected using direct-push sampling methods were analyzed for PAHs and VOCs. As summarized in Table 4-6, 16 PAHs were detected in groundwater. All PAHs were detected in greater than five percent of the samples in at least one depth interval. As summarized in Table 4-5, 32 VOCs were detected in one or more groundwater samples. Volatile organic compounds were detected in less than five percent of the samples including 1,1,1,2-tetrachloroethane, 1,1-dichloroethene, 1,2,3-trichloropropane, 1,2-dichlorobenzene, bromodichloromethane, chlorobenzene, dibromochloromethane, dichlorodifluoromethane, tetrachloroethene, trans-1,2-dichloroethene, and vinyl chloride.

As also discussed in Section 4.0, nine groundwater monitoring wells were sampled. Of these nine wells, three are located in Parcel 181 and six are located on adjacent properties. All monitoring well samples were analyzed for PAHs, VOCs, and methyl tertiary butyl ether

(MTBE). As summarized in Table 4-7 and Table 4-8, 10 PAHs, 14 VOCs and MTBE were detected in monitoring well samples. All of the VOCs listed above were detected in less than 5 percent of the direct-push samples analyzed, but were not detected in the monitoring well samples.

Methane was also detected in both direct-push and monitoring well groundwater samples. Because methane is a simple asphyxiant and a physical hazard rather than a chronic health hazard, it was not quantitatively evaluated in this risk assessment. Potential hazards other than chronic toxicity related to the presence of methane in groundwater are discussed in Section 5.9.8.

Because of the uncertainty in estimating the migration of volatile chemicals in soil and groundwater to indoor or ambient air, soil gas samples were also collected at the site during the RI. As discussed in Section 4.0, a total of 32 locations were sampled for soil gas. Of these locations, 17 were collected within OU-5 (including one sample on Parcel 182) and 15 were collected at the adjacent property. As summarized in Table 4-10, 21 VOCs were detected in soil gas. Of the 21, the following four were detected in only at the adjacent properties, 1,1,1-trichloroethane, chlorobenzene, chloroethane, and trichloroethene. Both chlorobenzene and chloroethane were detected in less than five percent of the samples.

All chemicals detected in groundwater and soil gas were selected for further evaluation in the risk assessment. The COPCs selected for further evaluation in the risk assessment are summarized in Table 5-1, "Chemicals Selected for Evaluation." As shown on this table, six of the PAHs are categorized as VOCs and ten as semivolatile organic compounds. The U.S. Coast Guard has recently collected indoor and ambient air samples at locations within the boundaries of OU-5 for the purpose of evaluating VOC concentrations. Although these data were no collected under the RI, these results are discussed in Section 5.9.8.

All data was reported either as unqualified, or with the following qualifiers: U, J, or UJ. Any data value that was qualified with "U," indicating a non-detect, reflects a sample-specific reporting limit for that particular analyte. Data qualified with "J," indicates an estimate. Quantified data are used to determine detection frequency and in calculating EPCs. Non-detect values were included in the EPC calculation by taking half the reported sample-specific detection limit, as stipulated in EPA guidance (1989). Calculation of EPCs is discussed in greater detail in Section 5.5.

5.5 Exposure Assessment

In evaluating the potential human health risks posed by a site, it is necessary to identify the populations that may potentially be exposed to the chemicals present and to determine the pathways by which these exposures may occur. Identification of the potentially exposed populations requires evaluating the human activity and land-use patterns at the site and in the vicinity of the site.

Once the potentially exposed populations are identified, the complete exposure pathways by which individuals in each of these potentially exposed populations may contact chemicals present in the soil and groundwater at the site are determined. An exposure pathway is defined as "the course a chemical or pollutant takes from the source to the organism exposed" (EPA, 1988). An exposure route is "the way a chemical or pollutant enters an organism after contact" (EPA, 1988). A complete exposure pathway requires the following four key elements:

- A chemical source
- A release mechanism and transport pathway to a point of contact
- An exposure medium (e.g., soil, air, or water)
- An exposure route (e.g., inhalation).

An exposure pathway is not complete unless all four elements are present. An incomplete exposure pathway does not require quantitative evaluation in the risk assessment.

A CSM is used to show the relationship between a chemical source, exposure pathway, and potential receptor at a site. The CSM identifies all potential or suspected chemical sources, potentially impacted media, and potential receptors. It also identifies the potential human exposure routes for contacting impacted media. These source-pathway-receptor relationships provide the basis for the quantitative exposure assessment. In fact, only those complete source-pathway-receptor relationships are included in the quantitative risk evaluation. The CSM for the site is shown on Figure 5-1.

Section 5.5.1 provides a description of the site and surrounding areas. Rationale for the selection of potentially exposed populations is discussed in Section 5.5.2 and for the relevant (i.e., complete) exposure pathways in Section 5.5.3. The methodology and assumptions used to quantify exposure are presented in Sections 5.5.4 and 5.5.5, respectively. Section 5.5.6 includes the calculated intake factors.

Table 5-1 (Page 1 of 2)
Chemicals Selected for Evaluation

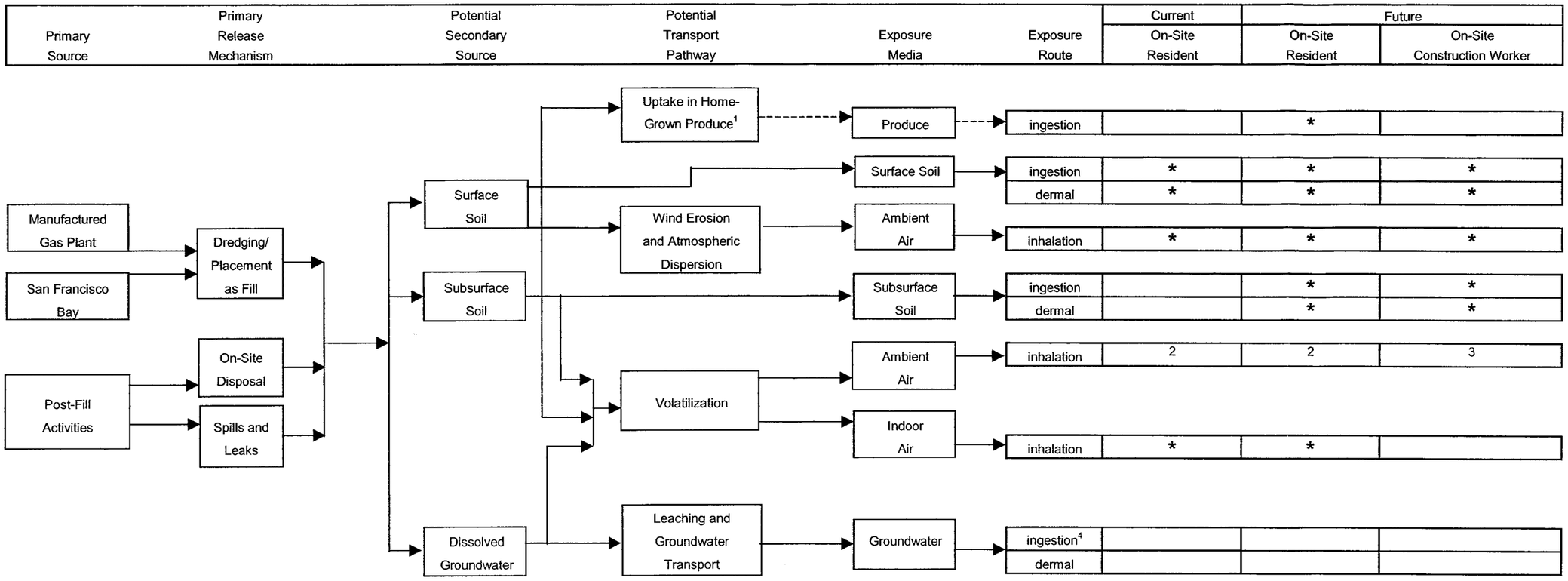
Chemical	Media		
	Soil	Groundwater	Soil Gas
Volatile Organic Compounds			
Acenaphthene	X	X	
Acetone			X
Anthracene	X	X	
Benzene		X	X
Bromodichloromethane		X	
2-Butanone (methyl ethyl ketone)		X	X
n-Butylbenzene		X	
sec-Butylbenzene		X	
Carbon Disulfide		X	
Chlorobenzene		X	X
Chloroethane			X
Chloroform		X	X
4-Chlorotoluene		X	
Dibromochloromethane		X	
1,2-Dichlorobenzene		X	
Dichlorodifluoromethane		X	
1,1-Dichloroethane			X
1,2-Dichloroethane		X	
1,1-Dichloroethene		X	X
cis-1,2-Dichloroethene		X	X
trans-1,2-Dichloroethene		X	
Ethylbenzene		X	X
Fluorene	X	X	
2-Hexanone			X
Isopropyl Benzene		X	
4-Isopropyltoluene		X	
Methylene Chloride		X	
4-Methyl-2-pentanone			X
Methyl tert-Butyl Ether		X	X
Naphthalene	X	X	X
Phenanthrene	X	X	
n-Propylbenzene		X	
Pyrene	X	X	
Styrene		X	X
1,1,1,2-Tetrachloroethane		X	
Tetrachloroethene		X	X
Toluene		X	X
1,1,1-Trichloroethane			X
Trichloroethene			X

Table 5-1 (Page 2 of 2)
Chemicals Selected for Evaluation

Chemical	Media		
	Soil	Groundwater	Soil Gas
Volatile Organic Compounds (continued)			
1,2,3-Trichloropropane		x	
1,2,4-Trimethylbenzene		x	
1,3,5-Trimethylbenzene		x	
Vinyl Acetate			x
Vinyl Chloride		x	
Xylenes[a]		x	x
Semivolatile Organic Compounds			
Acenaphthylene	x	x	
Benz(a)anthracene	x	x	
Benzo(a)pyrene	x	x	
Benzo(b)fluoranthene	x	x	
Benzo(g,h,i)perylene	x	x	
Benzo(k)fluoranthene	x	x	
Chrysene	x	x	
Dibenz(a,h)anthracene	x	x	
Fluoranthene	x	x	
Indeno(1,2,3-cd)pyrene	x	x	
Inorganic Compounds			
Antimony	x		
Arsenic	x		
Barium	x		
Beryllium	x		
Cadmium	x		
Chromium	x		
Cobalt	x		
Copper	x		
Lead	x		
Mercury	x		
Molybdenum	x		
Nickel	x		
Selenium	x		
Silver	x		
Thallium	x		
Vanadium	x		
Zinc	x		

[a] *Includes m-, o-, and p- isomers.*

Figure 5-1
Conceptual Site Model



Notes:

** Quantitatively evaluated in Baseline Risk Assessment*

1- Ingestion of homegrown produce is qualitatively evaluated in the Baseline Risk Assessment.

2- This pathway occurs but the indoor air exposure to volatile gases already provides a conservative estimate.

3- For the construction worker, ambient air in a trench during construction activities is evaluated.

4- Groundwater at the site is not considered to be suitable as a potable drinking water supply (TtEMI, 2000b).

5.5.1 Exposure Setting

The boundaries of OU-5 were shown on Figure 1-2. As shown in this figure, OU-5 consists of land Parcels 181 (North Village Housing Area), 182 (Coast Guard Housing Office and Estuary Park), and 183 (Coast Guard Housing Maintenance Office), within Alameda Point. The OU-5 area consists of housing areas with 51 multiple housing complexes and open-space park areas. Approximately 40 percent of the site is covered with structures and cement or asphalt paving. The remainder of the site is open space, covered with vegetation and soil.

In the near future, it is proposed that parcels within OU-5 will be transferred to the City of Alameda and will continue to be leased to the U.S. Coast Guard for use as Coast Guard housing.

5.5.2 Potential Receptors

Parcel 181 contains housing complexes that presently house Coast Guard personnel and their families. At the time this report was written, Coast Guard personnel and their families occupied approximately 80 percent of the Parcel 181 housing complexes. The remaining 20 percent were unoccupied. The housing areas generally contain between three and six individual units with small, individual front and back yards. Parcel 181 also has larger, common areas among the housing complexes with some playgrounds and lawns.

Parcel 182 is comprised of Estuary Park, an area formerly used for recreational purposes by the residents in OU-5. Estuary Park contains baseball and soccer fields, paved walkways, and expanses of lawn. At the time of this risk assessment, access to most of Estuary Park was restricted: a fence and posted signs prevented individuals from using approximately two-thirds of the property. Parcel 183 is less than one acre in size and contains Building 545, which is presently used as the Coast Guard Housing Maintenance Office. The Navy has already evaluated Parcels 182 and 183 and determined that they will undertake remedial action to reduce concentrations of PAHs where needed. Because these parcels have already been evaluated and a remedial effort planned, risk associated with chronic exposure to present-day soil concentrations in these areas is not quantified in this risk assessment.

This human health risk assessment will estimate the cancer risks and noncancer hazards associated with potential exposure to chemicals identified in soil, groundwater, and soil gas at the North Village Housing Area (Parcel 181) under current and possible future site conditions. The current scenario includes residents (adults and children) of the existing Coast Guard housing complexes. In addition, the property may be redeveloped as residential housing in the future under a different housing configuration. For this reason, future residents (adults and children) and construction workers are also identified as potential receptors.

Residents may also use common areas of Parcel 181 for recreational purposes. Although current residents may engage in recreational activities at OU-5, a separate evaluation of risks for a recreational user will not be made because the residential land-use scenario represents the greatest potential for exposure to site-related chemicals.

5.5.3 Exposure Pathways

Based on the CSM, exposure media at the site include soil and groundwater. Exposure pathways for each medium are discussed separately below. Since surface water bodies do not exist at the site, surface water does not constitute a potential exposure media and is not considered in this assessment.

5.5.3.1 Soil

Current and future on-site residents could be exposed directly to chemicals remaining in surface and near-surface soils. Potential routes of exposure to chemicals present in these soils include incidental ingestion, dermal contact, and inhalation of volatile chemicals and windblown particulates.

For current residents, exposure to chemicals in the 0 to 0.5 feet bgs, 0 to 2 feet bgs, and 0 to 4 feet bgs depth intervals were evaluated. The 0 to 0.5 foot interval is the most likely for direct contact by current residents. The 0 to 2 feet bgs and 0 to 4 feet bgs were evaluated to assess the consequences of potential contact with deeper soils during digging activities. According to EPA, typical activities of children and adults in a residential setting do not extend below about a foot (EPA, 2002). Twenty-four inches, or 2 feet, is generally considered adequate for gardening activities. Coast Guard residents are prohibited from growing vegetables on OU-5.

For future residents, exposure to chemicals in the 0 to 0.5 feet bgs, 0 to 2 feet bgs, 0 to 4 feet bgs, and 0 to 8 feet bgs depth intervals was evaluated. If the current buildings remain in the future, the 0 to 0.5 foot interval would be the most likely for direct contact. The 0 to 2 foot interval and 0 to 4 foot interval were evaluated assuming that soils to these depths may be mixed during redevelopment activities. Future residents could also be exposed to chemicals in soils at these depths through uptake into fruits or vegetables. This potential exposure pathway is not quantitatively evaluated in this risk assessment but is discussed is Section 5.9.8.

For a residential scenario, CalEPA has typically required the evaluation of potential exposure to soils to a depth of approximately 10 feet bgs (CalEPA, 1992). This ensures that the assessment considers any residential activity that could disturb deeper soils, such as installing a swimming pool. For this site, it is assumed that redevelopment activities will not occur below eight feet, the

approximate depth to groundwater. Although the 0 to 8 foot bgs interval has been included in this assessment, it is considered unlikely that redevelopment activities would mix soils to this depth over significant areas of the site.

In the ROD for the site, the Navy intends to restrict digging below 2 feet across all of OU-5. The restriction to digging will effectively eliminate the potential site-related risks due to direct contact with PAHs in soils below 2 feet in all areas in the future.

Current and future residents could also be exposed to VOCs that have migrated from subsurface soil through the overlying soil into indoor and ambient air. Potential exposures resulting from the inhalation of vapors that have migrated from the subsurface through the soil column will be quantified in this assessment for residents (indoor air) based on the soil gas sampling results collected at 2 feet bgs and 5 to 7 feet bgs. Only the inhalation of VOCs in indoor air was modeled for residential populations since outdoor concentrations of VOCs will be lower than indoor air concentrations due to higher mixing in the ambient environment.

Constructions workers could also be directly exposed to soils during redevelopment activities including trenching for foundations and placement of utility lines. Potential routes of exposure to soils include incidental ingestion, dermal contact, inhalation of volatile chemicals and windblown particulates. Exposure to chemicals in soil across the 0 to 8 foot depth interval is evaluated for construction workers, as it is possible that utility lines or foundations could reach this depth. Potential exposure of future construction workers resulting from inhalation of volatile chemicals during trenching will be quantified in this assessment using soil gas sampling results collected at 2 feet bgs and 5 to 7 feet bgs.

5.5.3.2 Groundwater

As discussed in the previous section, depth to groundwater at the site is approximately 8 feet bgs, with adequate shallow groundwater to obtain samples at approximately 10 to 12 feet bgs. At these depths, it is unlikely that either residents or construction workers would come in direct contact with groundwater on a consistent (i.e., chronic) basis. Use of groundwater as a municipal drinking water source is not considered a complete pathway for a resident or construction worker. A technical memorandum prepared for Alameda Point concluded that groundwater at OU-5 is not suitable as a potable drinking water supply (TtEMI, 2000a). In addition, the memorandum concluded that pretreatment of groundwater for crop irrigation was not feasible due to high total dissolved solids and that there is a low probability that the area will be used for livestock.

Residents may be exposed to VOCs in groundwater that migrate as vapors from groundwater, through soil, and into ambient or indoor air of buildings either via cracks in a cement slab or via a crawlspace. Potential exposures resulting from the inhalation of groundwater vapors that have migrated through the soil column will be quantified in this assessment for residents (indoor air) based on the soil gas sampling results collected at 2 feet bgs and 5 to 7 feet bgs. As with subsurface soil, only the inhalation of volatile chemicals in indoor air is modeled for residential populations since outdoor concentrations will be lower than indoor air concentrations due to higher mixing in the ambient environment.

In addition, the construction worker could be exposed to VOCs in shallow groundwater that migrates as vapors into a trench during construction activities. Potential exposure of future construction workers resulting from inhalation of vapors during trenching will be quantified in this assessment based on shallow groundwater samples collected using direct-push methods and from shallow groundwater monitoring wells. For the direct-push sampling locations, shallow groundwater (considered less than 12 feet bgs) was collected from the first water bearing zone. All monitoring well samples with screened intervals below 12 feet were also considered in this evaluation.

5.5.4 Exposure Factors and Intake Equations

Estimates of human intake are a function of exposure parameters such as duration, frequency, and contact rates. This section provides the equations and assumptions used to develop the intake factors used in the calculation of risks.

The EPA (1989) defines exposure as "the contact with a chemical or physical agent" and defines the magnitude of exposure as "the amount of an agent available at human exchange boundaries (i.e., lungs, gut, skin) during a specified time." Exposure assessments are designed to determine the degree of contact a person has with a chemical. This section presents the equations used to estimate chemical exposures or intakes.

The intake factor equation includes variables that characterize the contact rate, exposure time, exposure frequency, exposure duration, body weight, and exposure averaging time. Intake factors can be calculated using the following generalized equation:

$$I = \frac{Cx\,CR\,x\,ETx\,EF\,x\,ED}{BW\,x\,AT}$$

Where:

I	=	Intake of a chemical (milligram [mg] chemical/kilogram [kg] body weight-day)
C	=	Chemical concentration (milligrams per liter water, milligrams per kilogram (mg/kg) soil, or mg/cubic meter [m^3] air
CR	=	Contact Rate; the amount of medium contacted per unit time (e.g., m^3 air/hour or mg soil/day)
ET	=	Exposure Time (hours/day)
EF	=	Exposure Frequency (days/year)
ED	=	Exposure Duration (years)
BW	=	Body Weight (kg)
AT	=	Averaging Time; period over which exposure is averaged (days)

Tables 5-2 through 5-5 present the route-specific equations used in this assessment to evaluate soil and groundwater. The equations for exposure via inhalation of groundwater and soil vapors are presented in Table 5-2, "Intake Equations for Exposure Via Inhalation of Vapors" inhalation of windblown soil particulates in Table 5-3, "Intake Equations for Exposure Via Inhalation of Windblown Soil Particulates" incidental ingestion of soil in Table 5-4, "Intake Equations for Exposure Via Incidental Ingestion of Soil" and dermal contact with soil in Table 5-5, "Intake Equations for Exposure Via Dermal Contact with Soil." Exposure assumptions used to estimate intake factors for the potential receptors of concern are summarized below. Table 5-6, "Exposure Assumptions – EPA Methodology" provides these results based on the EPA methodology and Table 5-7, "Exposure Assumptions – CalEPA Methodology" provides these results based on the CalEPA methodology. Models used to estimate air concentrations are discussed in Section 5.6. The chemical concentrations used to evaluate potential exposures to residents and construction workers are presented in Section 5.7.

5.5.5 Exposure Assumptions

Assumptions for route-specific exposure parameters used in the intake equation in Section 5.5.4 can be separated into the following three categories:

- Assumptions regarding human physiology (e.g., body weight)
- Assumptions regarding receptor behavior (e.g., years in which an individual resides at the same location)
- Assumptions specific to the given route of exposure (e.g., amount of soil ingested each day).

For this risk assessment, exposure assumptions corresponding to a reasonable maximum exposure (RME) scenario were developed. Intake assumptions for the RME scenario represent "the highest exposure that is reasonably expected to occur at the site" (EPA, 1989).

According to the EPA, the intent of the RME scenario is "to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possible exposures" (EPA, 1989). The RME is estimated by combining "upper bound and mid-range exposure factors so that the results represent an exposure scenario that is both protective and reasonable; not the worst possible case" (EPA, 1989).

Where available and appropriate, exposure parameter values recommended by EPA (1989, 1991b, and 1997a) and CalEPA (1992, 1994) were used. For some exposure parameters, the agencies do not have recommended values or the default recommendations are not appropriate for the receptors being evaluated. In such cases, best professional judgment was used to select parameter values corresponding to the individual pathways and is so noted. The three categories of exposure assumptions are further discussed below.

5.5.5.1 Human Physiological Assumptions

For estimating potential exposures to the adult resident and construction worker, the physiological assumptions for a male adult have been used as recommended by EPA and CalEPA. Physiological assumptions used in this assessment include an adult body weight of 70 kg (EPA, 1991b; CalEPA, 1992). For adult residents, the RME breathing rate is 20 m^3/day or 0.83 m^3/hour (EPA, 1991b; CalEPA, 1992). For adult construction workers, the RME breathing rate is 20 m^3/8-hour workday or 2.5 m^3/hour (EPA, 1991b; CalEPA, 1992).

For the child resident, physiological assumptions for the average child from infancy to six years (i.e., 0 to six years) have been used. The child is assumed to have a body weight of 15 kg (EPA, 1991b; CalEPA, 1992). For the child resident, the RME breathing rate is 10 m^3/day or 0.42 m^3/hour (EPA, 1997a; CalEPA, 1994).

5.5.5.2 Population-Specific Assumptions

Assumptions regarding population-specific exposure time, frequency, duration, and averaging time are used to determine the pathway-specific chemical intakes for the potentially exposed receptors. Exposure time, frequency, and duration determine the total time of exposure for each receptor. For current residents, exposure duration is based on site-specific information. The RME default exposure duration is used for the potential future residents.

Table 5-2
Intake Equations for Exposure Via Inhalation of Vapors

INHALATION INTAKE (VOLATILES):

$$I_{vapors} = \frac{C \times BR \times TC \times ET \times EF \times ED}{BW \times AT}$$

I_{vapors}	=	Inhalation Intake, milligrams per kilogram (mg/kg) body weight-day
C	=	Chemical Concentration, milligrams per liter (mg/L) or mg/kg
BR	=	Breathing Rate, cubic meter (m^3)/hour
TC	=	Transfer Coefficient, (mg/m^3)/(mg/L) or (mg/m^3)/(mg/kg)
ET	=	Exposure Time, hours/day
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
BW	=	Body Weight, kilograms (kg)
AT	=	Averaging Time, days

INHALATION INTAKE (VOLATILES), AGE ADJUSTED (FOR CARCINOGENS ONLY):

$$I_{inh/adj} = \frac{C \times BR_{child} \times TC \times ET \times EF_{child} \times ED_{child}}{BW_{child} \times AT} + \frac{C \times BR_{adult} \times TC \times ET \times EF_{adult} \times ED_{adult}}{BW_{adult} \times AT}$$

$I_{inh/adj}$	=	Inhalation Intake, age adjusted, mg/kg body weight-day
C	=	Chemical Concentration, mg/L or mg/kg
BR_{child}	=	Breathing Rate, child, m^3/hour
BR_{adult}	=	Breathing Rate, adult, m^3/hour
TC	=	Transfer Coefficient, (mg/m^3)/(mg/L) or (mg/m^3)/(mg/kg)
ET_{child}	=	Exposure Time, child, hours/day
ET_{adult}	=	Exposure Time, adult, hours/day
EF_{child}	=	Exposure Frequency, child, days/year
EF_{adult}	=	Exposure Frequency, adult, days/year
ED_{child}	=	Exposure Duration, child, years
ED_{adult}	=	Exposure Duration, adult, years
BW_{child}	=	Body Weight, child, kg
BW_{adult}	=	Body Weight, adult, kg
AT	=	Averaging Time, days

Table 5-3
Intake Equations for Exposure Via Inhalation of Windblown Soil Particulates

INHALATION INTAKE (PARTICULATES):

$$I_{particulates} = \frac{C \times BR \times CF \times ET \times EF \times ED}{BW \times AT}$$

$I_{particulates}$	=	Inhalation Intake, milligrams per kilogram (mg/kg) body weight-day
C	=	Chemical Concentration, mg/kg
BR	=	Breathing Rate, cubic meters (m^3)/hour
CF	=	Correlation Factor, kg/m^3 (7.6×10^{-10} for residents; 7.0×10^{-7} for construction workers)
ET	=	Exposure Time, hours/day
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
BW	=	Body Weight, kg
AT	=	Averaging Time, days

INHALATION INTAKE (PARTICULATES), AGE ADJUSTED (FOR CARCINOGENS ONLY):

$$I_{inh/adj} = \frac{C \times BR_{child} \times CF \times ET \times EF_{child} \times ED_{child}}{BW_{child} \times AT} + \frac{C \times BR_{adult} \times CF \times ET \times EF_{adult} \times ED_{adult}}{BW_{adult} \times AT}$$

$I_{inh/adj}$	=	Inhalation Intake, age adjusted, mg/kg body weight-day
C	=	Chemical Concentration, mg/kg
BR_{child}	=	Breathing Rate, child, m^3/hour
BR_{adult}	=	Breathing Rate, adult, m^3/hour
CF	=	Correlation Factor, kg/m^3
ET_{child}	=	Exposure Time, child, hours/day
ET_{adult}	=	Exposure Time, adult, hours/day
EF_{child}	=	Exposure Frequency, child, days/year
EF_{adult}	=	Exposure Frequency, adult, days/year
ED_{child}	=	Exposure Duration, child, years
ED_{adult}	=	Exposure Duration, adult, years
BW_{child}	=	Body weight, child, kg
BW_{adult}	=	Body Weight, adult, kg
AT	=	Averaging Time, days

Table 5-4
Intake Equations for Exposure Via Incidental Ingestion of Soil

SOIL INGESTION INTAKE:

$$I_{ingestion} = \frac{C \times IR \times EF \times ED \times CF}{BW \times AT}$$

$I_{ingestion}$	=	Ingestion Intake, milligrams per kilogram (mg/kg) body weight-day
C	=	Chemical Concentration, mg/kg
IR	=	Ingestion Rate, mg soil/day
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
CF	=	Conversion Factor, kg/mg
BW	=	Body Weight, kg
AT	=	Averaging Time, days

SOIL INGESTION INTAKE, AGE ADJUSTED (FOR CARCINOGENS ONLY):

$$I_{ing/adj} = \frac{C \times IR_{child} \times EF_{child} \times ED_{child} \times CF}{BW_{child} \times AT} + \frac{C \times IR_{adult} \times EF_{adult} \times ED_{adult} \times CF}{BW_{adult} \times AT}$$

$I_{ing/adj}$	=	Ingestion Intake, age adjusted, mg/kg body weight-day
C	=	Chemical Concentration, mg/kg
IR_{child}	=	Soil Ingestion Rate, child, mg soil/day
IR_{adult}	=	Soil Ingestion Rate, adult, mg soil/day
EF_{child}	=	Exposure Frequency, child, days/year
EF_{adult}	=	Exposure Frequency, adult, days/year
ED_{child}	=	Exposure Duration, child, years
ED_{adult}	=	Exposure Duration, adult, years
CF	=	Conversion Factor, kg/mg
BW_{child}	=	Body Weight, child, kg
BW_{adult}	=	Body Weight, adult, kg
AT	=	Averaging Time, days

Table 5-5
Intake Equations for Exposure Via Dermal Contact with Soil

DERMAL INTAKE:

$$I_{dermal-soil} = \frac{C \times SA \times AF \times ABS \times EF \times ED \times CF}{BW \times AT}$$

$I_{dermal\ -\ soil}$	=	Dermal Intake, milligrams per kilogram (mg/kg) body weight-day
C	=	Chemical Concentration, mg/kg
SA	=	Surface Area of exposed skin, square centimeters (cm^2)/day
AF	=	Adherence Factor, mg/cm^2
ABS	=	Absorption Factor (unitless)
EF	=	Exposure Frequency, days/year
ED	=	Exposure Duration, years
CF	=	Conversion Factor, kg/mg
BW	=	Body Weight, kg
AT	=	Averaging Time, days

DERMAL INTAKE, AGE ADJUSTED (FOR CARCINOGENS ONLY):

$$I_{dermal/adj} = \frac{C \times SA_{child} \times AF_{child} \times ABS \times EF_{child} \times ED_{child} \times CF}{BW_{child} \times AT} + \frac{C \times SA_{adult} \times AF_{adult} \times ABS \times EF_{adult} \times ED_{adult} \times CF}{BW_{adult} \times AT}$$

$IF_{dermal/adj}$	=	Dermal Intake Factor, age adjusted, mg/kg body weight-day
C	=	Chemical Concentration, mg/kg
SA_{child}	=	Surface Area of exposed skin, child, cm^2/day
SA_{adult}	=	Surface Area of exposed skin, adult, cm^2/day
AF_{child}	=	Adherence Factor, child, mg/cm^2
AF_{adult}	=	Adherence Factor, child, mg/cm^2
ABS	=	Absorption Factor (unitless)
EF_{child}	=	Exposure Frequency, child, days/year
EF_{adult}	=	Exposure Frequency, adult, days/year
ED_{child}	=	Exposure Duration, child, years
ED_{adult}	=	Exposure Duration, adult, years
BW_{child}	=	Body Weight, child, kg
BW_{adult}	=	Body Weight, adult, kg
CF	=	Conversion Factor, kg/mg
AT	=	Averaging Time, days

Table 5-6 (Page 1 of 2)
Exposure Assumptions - EPA Methodology

Parameter	Potentially Exposed Populations				
	Current Resident		Future Resident		Future Construction Worker
	Adult	Child	Adult	Child	
Inhalation of Vapors/Particulates					
Inhalation Rate (m^3/hr)[a]	0.83	0.42	0.83	0.42	2.5
Exposure Time (hrs/day)[b]	24	24	24	24	8
Particulate Transfer Factor (kg/m^3)[c]	$7.6x10^{-10}$	$7.6x10^{-10}$	$7.6x10^{-10}$	$7.6x10^{-10}$	$6.94x10^{-7}$
Ingestion of Soil					
Ingestion Rate (mg/day)[d]	100	200	100	200	480
Conversion Factor (kg/mg)	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$
Dermal Contact with Soil					
Surface Area (cm^2/day)[e]	5,700	2,800	5,700	2,800	3,300
Adherence Factor (mg/cm^2)[f]	0.07	0.2	0.07	0.2	0.2
Absorption Factor-Organics (unitless)[g]	0.1	0.1	0.1	0.1	0.1
Absorption Factor-PAHs (unitless)[g]	0.13	0.13	0.13	0.13	0.13
Absorption Factor-metals (unitless)[g]	0.01	0.01	0.01	0.01	0.01
Absorption Factor-arsenic (unitless)[g]	0.03	0.03	0.03	0.03	0.03
Aborption Factor-cadmium (unitless)[g]	0.001	0.001	0.001	0.001	0.001
Conversion Factor (kg/mg)	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$
Population-Specific Assumptions					
Exposure Frequency - Soil (days/yr)[h]	350	350	350	350	125
Exposure Duration (years)[i]	6	6	30	6	1
Exposure Duration - Age-Adjusted (years)[j]	NA	NA	24	6	NA
Body Weight (kg)[k]	70	15	70	15	70
Averaging Time - Carcinogens (days)[l]	25,550	25,550	25,550	25,550	25,550
Averaging Time - Noncarcinogens (days)[m]	2,190	2,190	10,950	2,190	365

NA denotes Not applicable

PAH denotes polynuclear aromatic hydrocarbons

EPA denotes U.S. Environmental Protection Agency

PRG denotes preliminary remediation goal

hrs denotes hours

cm^2 denotes square centimeters

kg denotes kilograms

yr denotes year

mg denotes milligrams

Table 5-6 (Page 2 of 2)
Exposure Assumptions - EPA Methodology

a *Recommended breathing rates for adult (20 cubic meters per day [m^3/day]) and child (10 m^3/day) residents (EPA, 1997 and 1991).*

b *Residents are assumed to be exposed 24 hours/day, while workers are exposed for a standard eight hour shift (EPA, 1991).*

c *Particulate Transfer Factor is the inverse of the EPA Region 9 PRGs (EPA, 2000) particulate emission factor (PEF) for a residential scenario. For the construction worker, it is the inverse of the Regional Water Quality Control Board (2000) PEF for a construction-site scenario.*

d *Soil ingestion rates for adult residents, child residents, and occupational workers recommended for use by EPA (1991).*

e *For residents the surface area corresponds to the head, hands, forearms, and lower legs; for children, also includes feet (EPA, 2000). For the workers, it corresponds to the head, hands, and forearms (EPA, 2000).*

f *EPA recommended soil adherence factor (EPA, 2000).*

g *EPA recommended absorption factors (EPA 2000).*

h *Consistent with EPA (1991) guidance, an exposure frequency of 350 days per year is assumed for both the adult and child residents. Based on best professional judgment, it is assumed that the construction worker may potentially be exposed to the site constituents five days per week for 25 weeks (i.e., 125 days).*

i *Current residents are assumed to be exposed for 6 years, future adult and child residents are assumed to be exposed for 30 years and 6 years, respectively (EPA, 1991), while 1 year is assumed for the construction worker involved in short-term work at the site.*

j *For carcinogens, the resident duration is divided into 6 years of exposure as a child (0-6 years) and 24 years of exposure as adult (7-30 years) per EPA guidance (1991).*

k *Standard body weights for adults and children, 70 kg and 15 kg, respectively, were used (EPA, 1989 and 1991).*

l *Intakes for carcinogens are calculated by averaging the dose received over a lifetime (i.e., 70 years or 25,550 days)(EPA, 1989, 1991).*

m *For noncarcinogens, the averaging time used is the period of exposure expressed in days (EPA, 1989 and 1991).*

Table 5-7 (Page 1 of 2)
Exposure Assumptions - CalEPA Methodology

Parameter	Potentially Exposed Populations				
	Current Resident		Future Resident		Future
	Adult	Child	Adult	Child	Construction Worker
Inhalation of Vapors/Particulates					
Inhalation Rate (m^3/hr)[a]	0.83	0.42	0.83	0.42	2.5
Exposure Time (hrs/day)[b]	24	24	24	24	8
Particulate Transfer Factor (kg/m^3)[c]	$7.60x10^{-10}$	$7.60x10^{-10}$	$7.60x10^{-10}$	$7.60x10^{-10}$	$6.94x10^{-7}$
Ingestion of Soil					
Ingestion Rate (mg/day)[d]	100	200	100	200	480
Conversion Factor (kg/mg)	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$
Dermal Contact with Soil					
Surface Area (cm^2/day)[e]	5,700	**2,900**	5,700	**2,900**	**5,700**
Adherence Factor (mg/cm^2)[f]	0.07	0.2	0.07	0.2	**0.8**
Absorption Factor-Organics (unitless)[g]	0.1	0.1	0.1	0.1	0.1
Absorption Factor-PAHs (unitless) [g]	0.13	0.13	0.13	0.13	**0.15**
Absorption Factor-metals (unitless) [g]	0.01	0.01	0.01	0.01	0.01
Absorption Factor-arsenic (unitless) [g]	0.03	0.03	0.03	0.03	0.03
Aborption Factor-cadmium (unitless)[g]	0.001	0.001	0.001	0.001	0.001
Conversion Factor (kg/mg)	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$	$1.00x10^{-6}$
Population-Specific Assumptions					
Exposure Frequency - Soil (days/yr)[j]	350	350	350	350	125
Exposure Duration (years)[j]	6	6	30	6	1
Exposure Duration - Age-Adjusted (years)[k]	NA	NA	24	6	NA
Body Weight (kg)[l]	70	15	70	15	70
Averaging Time - Carcinogens (days)[m]	25,550	25,550	25,550	25,550	25,550
Averaging Time - Noncarcinogens (days)[n]	2,190	2,190	10,950	2,190	365

Table 5-7 (Page 2 of 2)
Exposure Assumptions - CalEPA Methodology

NA denotes Not applicable

a Recommended breathing rates for adult (20 m3/day) and child (10 m3/day) residents (EPA 1997; EPA 1991).

b Residents are assumed to be exposed 24 hours/day, while workers are exposed for a standard eight hour shift (EPA 1991).

c Particulate Transfer Factor is the inverse of the EPA Region 9 PRGs (EPA 2000) particulate emission factor (PEF) for a residential scenario. For the construction worker, it is the inverse of the Regional Water Quality Control Board (RWQCB 2000) PEF for a construction-site scenario.

d Soil ingestion rates for adult residents, child residents, and occupational workers recommended for use by EPA (1991).

e For residents the surface area corresponds to the head, hands, forearms, and lower legs; for children, also includes feet (EPA 2000); For the workers, it corresponds to the head, hands, and forearms (EPA 2000).

f EPA recommended soil adherence factor (EPA 2000).

g EPA recommended absorption factors (EPA 2000).

h Based on best professional judgment, it is assumed that the construction worker may potentially be exposed to groundwater during digging activities two hours per day, two days per week for 25 weeks (i.e., one half of one year or 50 days).

i Consistent with EPA (1991) guidance, an exposure frequency of 350 days per year is assumed for both the adult and child residents. Based on best professional judgment, it is assumed that the construction worker may potentially be exposed to the site constituents five days per week for 25 weeks (i.e., one half of one year or 125 days).

j Current residents are assumed to be exposed for 6 years, future adult and child residents are assumed to be exposed for 30 years and 6 years, respectively (EPA 1991), while 1 year is assumed for the construction worker involved in short-term work at the Site.

k For carcinogens, the resident duration is divided into 6 years of exposure as a child (0-6 years) and 24 years of exposure as adult (7-30 years) per EPA guidance (1991).

l Standard body weights for adults and children, 70 kg and 15 kg, respectively, were used (EPA 1989, 1991).

m Intakes for carcinogens are calculated by averaging the dose received over a lifetime (i.e., 70 years or 25550 days)(EPA 1989, 1991).

n For noncarcinogens, the averaging time used is the period of exposure expressed in days (EPA 1989, 1991).

Sources:

Regional Water Quality Control Board (RWQCB). 2000. Application of Risk-Based Screening Levels and Decision Making to Sites with Impacted Soil and Groundwater. San Francisco Bay Region. Oakland, CA. August.

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U.S. Environmental Protection Agency (EPA). 2000. Region 9 Preliminary Remediation Goals (PRGs). San Francisco, California. November 1.

For both the current and future residents, it is assumed that exposure occurs for 24 hours/day for all pathways (EPA, 1991b; CalEPA, 1992). Consistent with EPA (1991b) and CalEPA (1992) guidance, an exposure frequency of 350 days per year is assumed for adult and child residents, both current and future. This assumes that residents are present in their home seven days a week for 50 weeks a year (or approximately 96 percent of the time). Approximately two weeks (or 15 days) are spent away from home.

Current residents, Coast Guard personnel and their families, are assigned to the site for a minimum of three years. According to the Coast Guard Housing Office, the typical stay is four years and the maximum length of stay is approximately nine years. For this risk assessment, an exposure duration of six years is used to evaluate the current resident. This value was chosen to be a conservative (but not worst case) estimate of the length of stay and also corresponds to the default child exposure duration (i.e., 0 to 6 years). The exposure duration for the future resident is assumed to be 30 years (EPA, 1991b and 1997a; CalEPA, 1992). According to EPA (1997a), this is the United States population 95th percentile for time spent at one residence.

For the current resident, noncarcinogenic and carcinogenic effects were calculated for both a six-year child exposure duration and a six-year adult exposure duration. For noncarcinogenic effects, it is assumed that the adult and child future residents are exposed for 30 years and six years, respectively. For carcinogenic effects, an age-adjusted intake factor was calculated which takes into account the differences in route-specific intake rates, body weights, and exposure duration for children and adults. The 30-year future residential exposure duration for carcinogenic effects is a composite of exposure assumptions for six years as a child and 24 years as an adult. These assumptions allow for the possibility that the 30 years an individual is assumed to live in the area may cover from childhood to adulthood. Regulatory guidance recommends this age-adjusted approach (EPA, 1991b).

For future construction workers at the site, exposure time, frequency and duration are estimated using conservative assumptions and professional judgment. It is assumed that the construction worker may potentially be exposed to the site-related chemicals five days per week for 25 weeks per year. In accordance with EPA (1991b) and CalEPA (1992) guidance, the exposure time for occupational workers is assumed to be eight hours per day, indicative of a standard shift. The exposure duration is assumed to be one year for the construction worker involved in short-term work at the site.

The averaging time selected for estimating chemical intake for a particular exposed population depends on the type of effect being assessed. In accordance with regulatory guidance

(EPA, 1989 and 1991b), intakes for carcinogens are calculated by averaging the dose received during the exposure period over a lifetime (i.e., 70 years or 25,550 days). As indicated in regulatory guidance for noncarcinogens, the averaging time used is the period of exposure expressed in days. The basis for the use of different averaging times for carcinogens and noncarcinogens is related to the currently held scientific opinion that the mechanisms of action for the two categories of chemicals are different.

5.5.5.3 Route-Specific Assumptions

Exposures to populations at the site may potentially occur from inhalation of soil and groundwater vapors, inhalation of airborne soil particulates, incidental ingestion of soil, and dermal contact with soil. The route-specific assumptions used to characterize the intake for each population and exposure pathway are presented below.

It is assumed that residents and construction workers may be exposed to VOCs migrating from subsurface soil or groundwater and windblown particulates via the inhalation route. Breathing rates for this route of exposure were discussed above.

Incidental ingestion of soil and dust is highly dependent on the type of activity being performed and the age of the receptor. For current and future residents, the RME soil ingestion rate is 100 mg/day for adults and 200 mg/day for children (EPA, 1991b; CalEPA, 1992). In accordance with risk assessment guidance (EPA, 1991b), the soil ingestion rate for construction workers is assumed to be 480 mg/day.

Exposure via dermal contact may result from the deposition of soil particles onto skin and the subsequent absorption of chemicals present in the deposited soil through the skin. For residents, the total exposed surface area assumes exposure to soil via head, hands, forearms, and lower legs (EPA, 1998). The total exposed surface area of these body parts is 5,700 square centimeters (cm^2) for an adult. For a child, the total exposed surface area is assumed to be 2,800 cm^2 for the EPA methodology (EPA, 2000a) and 2,900 cm^2 for the CalEPA methodology (CalEPA, 2000). Since construction workers are assumed to be wearing more protective clothing, the exposed surface area is assumed to be 3,300 cm^2 for the EPA methodology (EPA, 1998) and 5,700 cm^2 for the CalEPA methodology (CalEPA, 2000).

Since only a portion of the soil that comes in contact with the skin of exposed individuals will remain there to be absorbed, dermal adherence factors are used. The dermal adherence factor for soil is 0.07 mg/cm^2 for adults and 0.2 mg/cm^2 for children (EPA, 2000a; CalEPA, 2000). For construction workers, the dermal adherence factor is assumed to be 0.2 mg/cm^2 for the EPA methodology (EPA, 2000a) and 0.8 mg/cm^2 for the CalEPA methodology (CalEPA, 2000).

To estimate uptake of chemicals through the skin, EPA Region 9 (2000b) uses default and chemical-specific dermal absorption factors, when available. In addition to the default values given for organic chemicals (0.1) and metals (0.01), specific values for PAHs (0.13), cadmium (0.001), and arsenic (0.03) are included in this assessment (EPA, 2000b). As CalEPA uses a more conservative dermal absorption factor for PAHs, this value (0.15) is used for the CalEPA methodology (1994).

5.5.6 Quantification of Exposure

As shown in Table 5-6 and Table 5-7, the only differences between the EPA methodology and CalEPA methodology in terms of exposure assumptions are the surface area for dermal contact (child and construction worker), the adherence factor (construction worker), and the absorption factor for PAHs. Using the route-specific equations presented in Tables 5-2 through 5-5 and the exposure assumptions presented in Table 5-6 and Table 5-7 intake factors were calculated for the potential exposure routes and populations of concern. Intake factors may be used in conjunction with medium-specific EPCs to quantify intake for each COPC and exposure pathway.

The intake factors are presented in Table 5-8, "Calculated Intake Factors for Carcinogens and Noncarcinogens – EPA Methodology" and Table 5-9, "Calculated Intake Factors for Carcinogens and Noncarcinogens – CalEPA Methodology" for both carcinogenic and noncarcinogenic effects. The intake factors presented in the tables employ the equations given in Tables 5-2 through 5-5, without the chemical specific concentrations and transfer coefficients. In addition, intake factors for adults also differ because of the age-adjustment used in the calculation for carcinogens. The age-adjustment estimates that of the 30-year exposure duration, 6 years are spent as a child and 24 years are spent as an adult. Thus, adding the carcinogen intake factors for a child and an adult yield the age-adjusted carcinogen intake factor. This adjustment is not necessary for noncarcinogens. The chemical EPCs used to evaluate potential exposures to residents and construction workers are discussed in Section 5.7.

5.6 Fate and Transport Modeling

The purpose of this section is to develop the inter-media fate and transport factors needed to quantify risk. These factors are derived using standard fate and transport models that estimate the movement of chemicals between environmental media. The specific pathway for which chemical migration is modeled depends on the potential sources of exposure, the relevant chemical migration pathways, the potentially exposed populations, the potential human exposure routes, and the specific chemicals addressed in the risk assessment. Based on the potential

pathways identified in the CSM described in Section 5.5, the following inter-media migration pathways of chemicals were evaluated:

- Movement of VOCs from soil gas into indoor air
- Movement of VOCs from soil gas into trench air
- Movement of VOCs from shallow groundwater through soil and into trench air
- Movement of non-volatile chemicals adsorbed to soil particulates into ambient air.

For this assessment, two different models have been used to estimate migration of VOCs from soil gas into indoor air for a residential scenario. These models were VLEACH (EPA, 1996) and Johnson and Ettinger (EPA, 2000b). The VLEACH model was used for the EPA methodology and, at the request of Department of Toxic Substances Control (DTSC), the Johnson and Ettinger model was used for the CalEPA methodology. Because of limitations with the Johnson and Ettinger spreadsheet, VLEACH was used to estimate the migration of chemicals from soil gas and groundwater into a trench for both methodologies. These two models will be discussed separately below.

Section 5.6.1 discusses the use of the VLEACH model to calculate transfer coefficients from soil gas and groundwater into indoor air and trench air. Section 5.6.2 discusses the Johnson and Ettinger model (EPA, 2000a) and its use in calculating indoor air concentrations. Because these two models use similar data to arrive at similar results using somewhat different techniques, Figure 5-2 presents flowcharts of their methodologies for indoor air that can be used for reference in these two sections and to compare the two methods. Figure 5-3 presents the flowchart for trench air. Finally, Section 5.6.3 presents the correlation factor calculated for non-volatile chemicals in surface soil to which individuals may be exposed via the inhalation of windblown dust.

5.6.1 Migration of Volatile Chemicals – VLEACH

To evaluate inhalation exposure to volatile chemicals in air, transfer factors that link the concentration of chemicals in soil gas to concentrations expected in indoor air and chemicals in shallow groundwater to concentrations in trench air were developed. Soil gas-to-indoor and trench air and groundwater-to-trench air transfer factors were developed for VOCs in this assessment through a series of two steps. The first step, outlined in Section 5.6.1.1 below, consists of estimating volatile emissions from site soil gas and groundwater. Under the EPA methodology, the EPA-approved vapor model VLEACH (1996) was used in this step. Because VLEACH does not allow a soil gas source to be input, the evaluation of soil gas-to-air transfer coefficients was carried out by assuming that the source of soil gas is a steady-state groundwater

Table 5-8
Calculated Intake Factors for Carcinogens and Noncarcinogens - EPA Methodology (a)

Exposure Scenario	Current Resident		Future Resident		Future Construction Worker
	Adult	Child	Adult	Child	
Carcinogen					
Inhalation of Vapors (m^3 air/kg body weight-day)	2.35×10^{-2}	5.48×10^{-2}	9.39×10^{-2}	5.48×10^{-2}	1.40×10^{-3}
Inhalation of Airborne Particulates (kg soil/kg body weight-day)	1.78×10^{-11}	4.16×10^{-11}	7.14×10^{-11}	4.16×10^{-11}	9.70×10^{-10}
Ingestion of Soil (kg soil/kg body weight-day)	1.17×10^{-7}	1.10×10^{-6}	4.70×10^{-7}	1.10×10^{-6}	3.35×10^{-8}
Dermal Contact with Soil - Organics (kg soil/kg body weight-day)	4.68×10^{-8}	3.07×10^{-7}	1.87×10^{-7}	3.07×10^{-7}	4.61×10^{-9}
Dermal Contact with Soil - PAHs (kg soil/kg body weight-day)	6.09×10^{-8}	3.99×10^{-7}	2.44×10^{-7}	3.99×10^{-7}	6.00×10^{-9}
Dermal Contact with Soil - Metals (kg soil/kg body weight-day)	4.68×10^{-9}	3.07×10^{-8}	1.87×10^{-8}	3.07×10^{-8}	4.61×10^{-10}
Dermal Contact with Soil - Arsenic (kg soil/kg body weight-day)	1.41×10^{-8}	9.21×10^{-8}	5.62×10^{-8}	9.21×10^{-8}	1.38×10^{-9}
Dermal Contact with Soil - Cadmium (kg soil/kg body weight-day)	4.68×10^{-10}	3.07×10^{-9}	1.87×10^{-9}	3.07×10^{-9}	4.61×10^{-11}
Noncarcinogen					
Inhalation of Vapors (m^3 air/kg body weight-day)	2.74×10^{-1}	6.39×10^{-1}	2.74×10^{-1}	6.39×10^{-1}	9.78×10^{-2}
Inhalation of Airborne Particulates (kg soil/kg body weight-day)	2.08×10^{-10}	4.86×10^{-10}	2.08×10^{-10}	4.86×10^{-10}	6.79×10^{-8}
Ingestion of Soil (kg soil/kg body weight-day)	1.37×10^{-6}	1.28×10^{-5}	1.37×10^{-6}	1.28×10^{-5}	2.35×10^{-6}
Dermal Contact with Soil - Organics (kg soil/kg body weight-day)	5.47×10^{-7}	3.58×10^{-6}	5.47×10^{-7}	3.58×10^{-6}	3.23×10^{-7}
Dermal Contact with Soil - PAHs (kg soil/kg body weight-day)	7.11×10^{-7}	4.65×10^{-6}	7.11×10^{-7}	4.65×10^{-6}	4.20×10^{-7}
Dermal Contact with Soil - Metals (kg soil/kg body weight-day)	5.47×10^{-8}	3.58×10^{-7}	5.47×10^{-8}	3.58×10^{-7}	3.23×10^{-8}
Dermal Contact with Soil - Arsenic (kg soil/kg body weight-day)	1.64×10^{-7}	1.07×10^{-6}	1.64×10^{-7}	1.07×10^{-6}	9.69×10^{-8}
Dermal Contact with Soil - Cadmium (kg soil/kg body weight-day)	5.47×10^{-9}	3.58×10^{-8}	5.47×10^{-9}	3.58×10^{-8}	3.23×10^{-9}

PAH denotes polynuclear aromatic hydrocarbons

m^3 denotes cubic meters

kg denotes kilograms

(a) The intake factors presented in the table employ the equations given in Tables 5-2 through 5-5, without the chemical specific concentrations and transfer coefficients. In addition, intake factors for adults also differ because of the age-adjustment used in the calculation for carcinogens. The age-adjustment estimates that of the 30-year exposure duration, 6 years are spent as a child and 24 years are spent as an adult. Thus, adding the carcinogen intake factors for a child and an adult yield the age-ajusted carcinogen intake factor. This adjustment is not necessary for noncarcinogens.

Table 5-9
Calculated Intake Factors for Carcinogens and Noncarcinogens - CalEPA Methodology (a)

Exposure Scenario	Current Resident		Future Resident		Future Construction Worker
	Adult	Child	Adult	Child	
Carcinogen					
Inhalation of Vapors (m^3 air/kg body weight-day)	$2.35x10^{-2}$	$5.48x10^{-2}$	$9.39x10^{-2}$	$5.48x10^{-2}$	$1.40x10^{-3}$
Inhalation of Airborne Particulates (kg soil/kg body weight-day)	$1.78x10^{-11}$	$4.16x10^{-11}$	$7.14x10^{-11}$	$4.16x10^{-11}$	$9.70x10^{-10}$
Ingestion of Soil (kg soil/kg body weight-day)	$1.17x10^{-7}$	$1.10x10^{-6}$	$4.70x10^{-7}$	$1.10x10^{-6}$	$3.35x10^{-8}$
Dermal Contact with Soil - Organics (kg soil/kg body weight-day)	$4.68x10^{-8}$	$3.18x10^{-7}$	$1.87x10^{-7}$	$3.18x10^{-7}$	$3.19x10^{-8}$
Dermal Contact with Soil - PAHs (kg soil/kg body weight-day)	$6.09x10^{-8}$	$4.13x10^{-7}$	$2.44x10^{-7}$	$4.13x10^{-7}$	$4.78x10^{-8}$
Dermal Contact with Soil - Metals (kg soil/kg body weight-day)	$4.68x10^{-9}$	$3.18x10^{-8}$	$1.87x10^{-8}$	$3.18x10^{-8}$	$3.19x10^{-9}$
Dermal Contact with Soil - Arsenic (kg soil/kg body weight-day)	$1.41x10^{-8}$	$9.53x10^{-8}$	$5.62x10^{-8}$	$9.53x10^{-8}$	$9.56x10^{-9}$
Dermal Contact with Soil - Cadmium (kg soil/kg body weight-day)	$4.68x10^{-10}$	$3.18x10^{-9}$	$1.87x10^{-9}$	$3.18x10^{-9}$	$3.19x10^{-10}$
Noncarcinogen					
Inhalation of Vapors (m^3 air/kg body weight-day)	$2.74x10^{-1}$	$6.39x10^{-1}$	$2.74x10^{-1}$	$6.39x10^{-1}$	$9.78x10^{-2}$
Inhalation of Airborne Particulates (kg soil/kg body weight-day)	$2.08x10^{-10}$	$4.86x10^{-10}$	$2.08x10^{-10}$	$4.86x10^{-10}$	$6.79x10^{-8}$
Ingestion of Soil (kg soil/kg body weight-day)	$1.37x10^{-6}$	$1.28x10^{-5}$	$1.37x10^{-6}$	$1.28x10^{-5}$	$2.35x10^{-6}$
Dermal Contact with Soil - Organics (kg soil/kg body weight-day)	$5.47x10^{-7}$	$3.71x10^{-6}$	$5.47x10^{-7}$	$3.71x10^{-6}$	$2.23x10^{-6}$
Dermal Contact with Soil - PAHs (kg soil/kg body weight-day)	$7.11x10^{-7}$	$4.82x10^{-6}$	$7.11x10^{-7}$	$4.82x10^{-6}$	$3.35x10^{-6}$
Dermal Contact with Soil - Metals (kg soil/kg body weight-day)	$5.47x10^{-8}$	$3.71x10^{-7}$	$5.47x10^{-8}$	$3.71x10^{-7}$	$2.23x10^{-7}$
Dermal Contact with Soil - Arsenic (kg soil/kg body weight-day)	$1.64x10^{-7}$	$1.11x10^{-6}$	$1.64x10^{-7}$	$1.11x10^{-6}$	$6.69x10^{-7}$
Dermal Contact with Soil - Cadmium (kg soil/kg body weight-day)	$5.47x10^{-9}$	$3.71x10^{-8}$	$5.47x10^{-9}$	$3.71x10^{-8}$	$2.23x10^{-8}$

PAH denotes polynuclear aromatic hydrocarbons

kg denotes kilograms

(a) The intake factors presented in the table employ the equations given in Tables 5-2 through 5-5, without the chemical specific concentrations and transfer coefficients. In addition, intake factors for adults also differ because of the age-adjustment used in the calculation for carcinogens. The age-adjustment estimates that of the 30-year exposure duration, 6 years are spent as a child and 24 years are spent as an adult. Thus, adding the carcinogen intake factors for a child and an adult yield the age-ajusted carcinogen intake factor. This adjustment is not necessary for noncarcinogens.

Figure 5-2
Transport Modeling From Soil Gas to Indoor Air: VLEACH vs Johnson & Ettinger

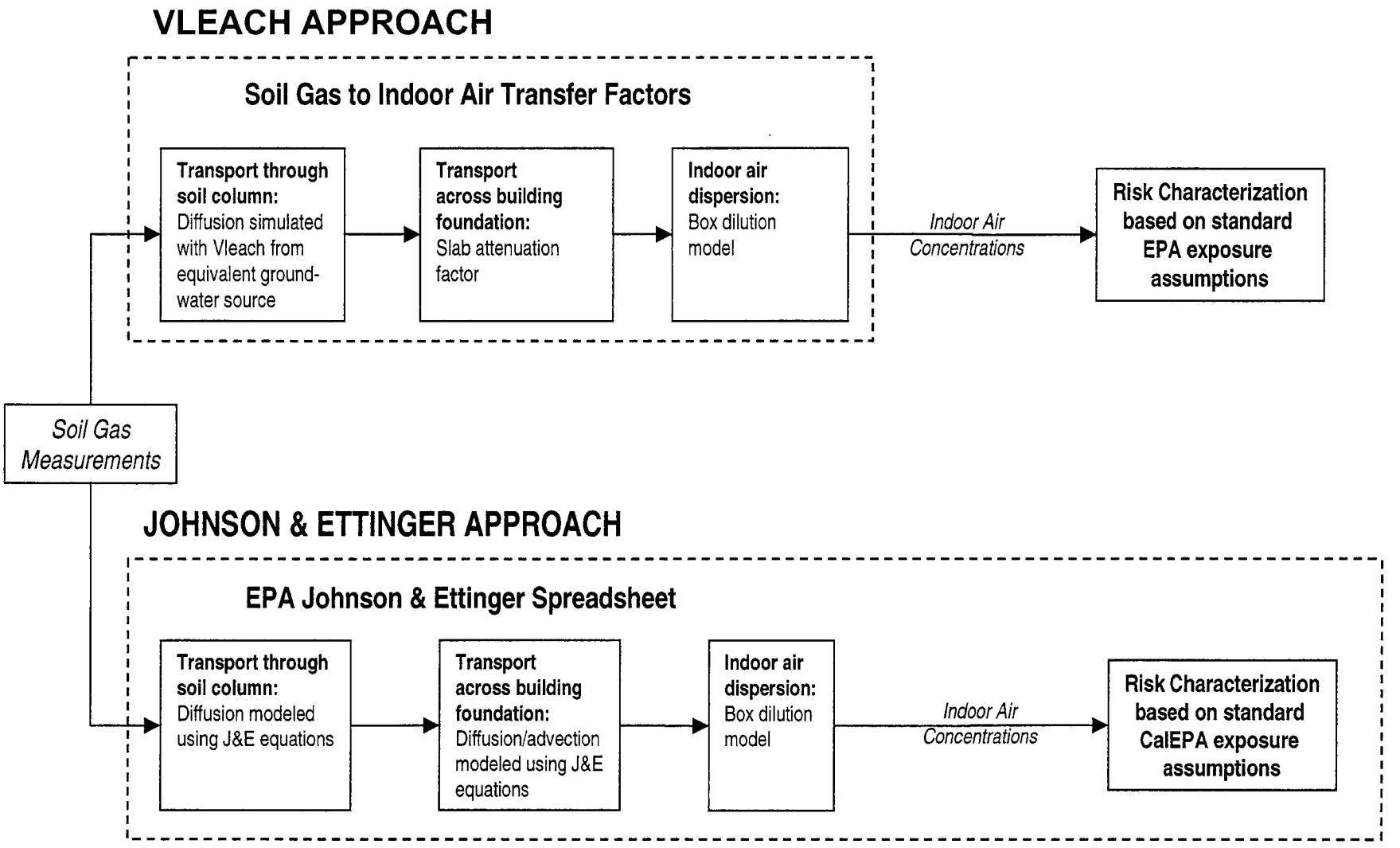
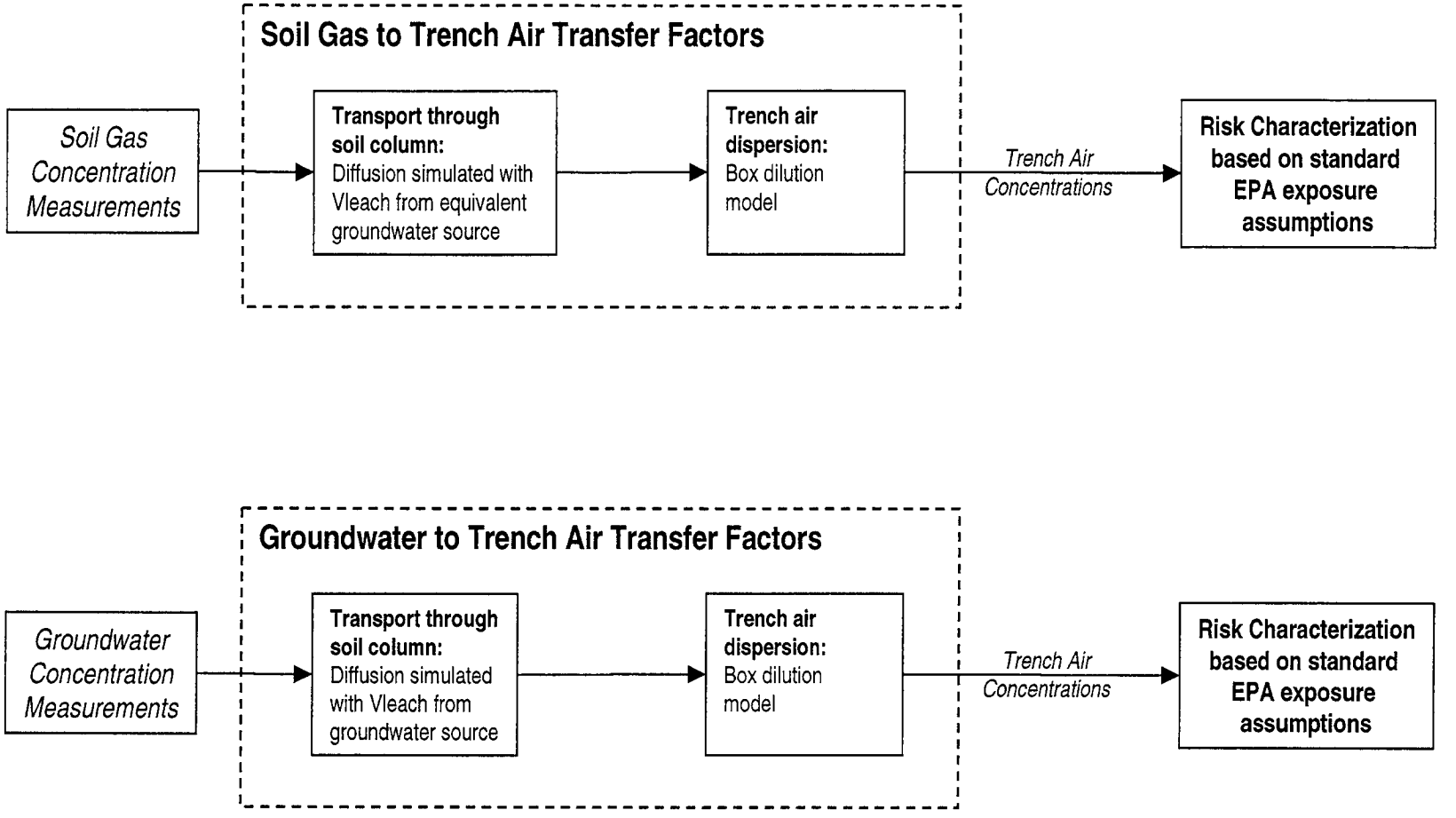


Figure 5-3
Transport Modeling From Soil Gas/Groundwater to Trench: VLEACH Approach



concentration that volatilizes up through the soil and creates a steady-state soil gas concentration. The second step, outlined in Section 5.6.1.2 below, consists of calculating the resulting air concentrations using an air dispersion model.

A soil gas-to-air transfer factor is defined as the average exposure concentration in air that would result from a unit concentration (i.e., 1 micrograms per cubic meter [$\mu g/m^3$]) of a chemical in soil gas. Similarly, a groundwater-to-air transfer factor is defined as the steady-state exposure concentration in air that would result from a unit concentration (i.e., 1 milligrams per liter [mg/L]) of a given chemical in groundwater. The resulting volatilization transfer factors from this evaluation are in units of $(mg/m^3_{air})/(\mu g/m^3_{soil\ gas})$ and $(mg/m^3_{air})/(mg/L_{water})$, respectively. The transfer factors are used to calculate the estimated air concentrations, which will result from the measured concentrations in soil gas or groundwater at the site. For example, to find the trench air concentration resulting from a chemical in groundwater, the measured groundwater concentration is multiplied by the groundwater-to-trench-air transfer factor. Air concentrations for the other migration pathways are calculated in a similar manner using the appropriate transfer factors.

5.6.1.1 Emission Flux

For the EPA methodology, the transport of chemicals from soil and groundwater to indoor and trench air was modeled as a flux with units of mass/area-time using the EPA-approved transport model VLEACH (EPA, 1996). VLEACH simulates the movement of a chemical within and among different environmental media: soil particles, groundwater, soil pore water, and air. VLEACH has the particular benefit of providing intermediate concentrations in each of these media, including soil and soil gas concentrations at different depths within the soil column. This allows it to simulate migration into a trench built into the soil, something that the Johnson and Ettinger spreadsheet model (EPA, 2000a), discussed in Section 5.6.2, is not designed to do. Both of these models simulate vertical transport through the soil by diffusion in the vapor phase, but do it in slightly different ways. Because of agency preferences, the Johnson and Ettinger model was used to carry out the same modeling scenarios as VLEACH, except for the trench scenario. This redundancy of modeling provides a way to characterize the difference between models, though it was not done for this purpose.

Emission modeling from VLEACH was carried out for releases from groundwater and releases from soil gas. In both cases, the mobility of chemicals in soil is governed by chemical-specific and site-specific soil properties. Relevant chemical-specific properties include:

- Diffusivity in air (which indicates how rapidly a chemical can move through the air due to a concentration gradient)
- Henry's law constant (which indicates the equilibrium amount of a chemical that exists in air relative to water)
- Organic carbon partition coefficient (which indicates how much a chemical sorbs to the organic carbon in soil).

Chemical-specific properties are usually available in the literature or are easily estimated. The chemical-specific physical/chemical properties used in this assessment are shown in Table 5-10, "Physical/Chemical Properties for Volatile Organic Compounds."

The soil properties that affect the flux of a chemical through soil include:

- Organic carbon content and bulk density (which help determine how much organic material is available for chemicals to sorb onto),
- Porosity and moisture content (which together identify how much air space is available for the gaseous migration of chemicals).

With these chemical and soil properties available, VLEACH modeling is carried out for the two release scenarios.

The groundwater release scenario is straightforward, involving the use of a constant groundwater concentration at the base of the vadose zone soils. The constant groundwater concentration feeds volatilization into the soil column and into overlying air spaces, such as a trench, a building, or outdoor air at ground surface. The resulting steady-state vapor flux is then inserted into an air dispersion model. In the groundwater release case, the flux is used with the trench air dispersion model discussed in Section 5.6.1.2.

The soil gas release scenario is less straightforward because VLEACH does not include a soil gas source in its input. However, because VLEACH outputs soil gas concentrations as a result of a constant groundwater source, an effective steady-state soil gas source can be evaluated using a constant groundwater source. The procedure ends up identical to that for a groundwater release scenario, except that the resulting groundwater-to-air transfer coefficient is divided by a groundwater-to-soil gas transfer coefficient (obtained from VLEACH) to get the desired soil

Table 5-10 (Page 1 of 2)
Physical/Chemical Properties for Volatile Organic Compounds*

Chemical	Molecular Weight (g/mole)	Henry's Law Constant ($atm\text{-}m^3/mole$)	Diffusivity in Air (cm^2/s)	Diffusivity in Water (cm^2/s)	Organic Carbon Partition Coefficient (L/kg)	Solubility (mg/L)
Acenaphthene	100 [c]	1.60×10^{-4} [c]	4.21×10^{-2} [d]	7.69×10^{-6} [d]	7.08×10^{3} [d]	4.20×10^{0} [c]
Acetone	58 [c]	3.90×10^{-5} [c]	1.24×10^{-1} [d]	1.14×10^{-5} [d]	5.75×10^{-1} [d]	1.00×10^{6} [c]
Anthracene	178 [c]	6.50×10^{-5} [c]	3.24×10^{-2} [d]	7.74×10^{-6} [d]	2.95×10^{4} [d]	4.30×10^{-2} [c]
Benzene	78 [c]	5.60×10^{-3} [c]	8.80×10^{-2} [d,e]	9.80×10^{-6} [d,e]	5.89×10^{1} [d]	1.75×10^{3} [c]
Bromodichloromethane	164 [c]	1.60×10^{-3} [c]	2.98×10^{-2} [d]	1.06×10^{-5} [d]	5.50×10^{1} [d]	6.70×10^{3} [c]
2-Butanone	72 [c]	5.60×10^{-5} [c]	8.95×10^{-2} [e]	9.80×10^{-6} [e]	4.50×10^{0} [e]	2.20×10^{5} [d]
n-Butylbenzene	134 [f]	1.31×10^{-2} [f]	7.50×10^{-2} [b]	7.80×10^{-6} [e]	2.83×10^{3} [j,f]	1.38×10^{1} [f]
sec-Butylbenzene	134 [f]	1.87×10^{-2} [f]	7.50×10^{-2} [b]	7.80×10^{-6} [e]	2.15×10^{3} [l]	1.70×10^{1} [f]
Carbon Disulfide	76 [c]	3.00×10^{-2} [c]	1.04×10^{-1} [d]	1.00×10^{-5} [d,e]	4.57×10^{1} [d]	1.19×10^{3} [c]
Chlorobenzene	113 [c]	3.70×10^{-3} [c]	7.30×10^{-2} [d]	8.70×10^{-6} [d]	2.19×10^{2} [d]	4.70×10^{2} [c]
Chloroethane	65 [f]	1.11×10^{-2} [p]	1.00×10^{-1} [e]	1.20×10^{-5} [e]	1.47×10^{1} [e]	5.74×10^{3} [f]
Chloroform	119 [c]	3.70×10^{-3} [c]	1.04×10^{-1} [d]	1.00×10^{-5} [d,e]	3.98×10^{1} [d]	7.92×10^{3} [c]
4-Chlorotoluene	127 [o]	3.50×10^{-3} [o]	7.20×10^{-2} [o]	8.70×10^{-6} [o]	1.60×10^{2} [o]	4.70×10^{2} [o]
1,2-Dichlorobenzene	147 [c]	1.90×10^{-3} [c]	6.90×10^{-2} [d]	7.90×10^{-6} [d,e]	6.17×10^{2} [d]	1.56×10^{2} [c]
Dibromochloromethane**	208 [c]	7.80×10^{-4} [c]	1.96×10^{-2} [d]	1.05×10^{-5} [d]	6.31×10^{1} [d]	2.60×10^{3} [c,d]
Dichlorodifluoromethane	121 [c]	3.40×10^{-1} [c]	8.00×10^{-2} [e]	1.05×10^{-5} [e]	5.80×10^{1} [e]	2.80×10^{2} [c,e]
1,1-Dichloroethane	99 [c]	5.60×10^{-3} [c]	7.42×10^{-2} [d]	1.05×10^{-5} [d]	3.16×10^{1} [d]	5.10×10^{3} [c]
1,2-Dichloroethane	99 [c]	9.80×10^{-4} [c]	1.04×10^{-1} [d]	9.90×10^{-6} [d,e]	1.74×10^{1} [d]	8.52×10^{3} [d]
1,1-Dichloroethene	97 [c]	2.60×10^{-2} [c]	9.00×10^{-2} [d]	1.04×10^{-5} [d]	5.89×10^{1} [d]	2.30×10^{3} [c]
cis-1,2-Dichloroethene	97 [c]	4.10×10^{-3} [c]	7.36×10^{-2} [d]	1.13×10^{-5} [d,e]	3.55×10^{1} [d]	3.50×10^{3} [d,c,e]
trans-1,2-Dichloroethene	97 [c]	9.40×10^{-3} [c]	7.02×10^{-2} [d]	1.19×10^{-5} [d]	5.25×10^{1} [d]	6.30×10^{3} [c]
Ethylbenzene	106 [c]	7.90×10^{-3} [c,e]	7.50×10^{-2} [d,e]	7.80×10^{-6} [d,e]	3.63×10^{2} [d]	1.69×10^{2} [c]
Fluorene	166 [c]	6.40×10^{-5} [c]	3.63×10^{-2} [d]	7.88×10^{-6} [d]	1.38×10^{4} [d]	2.00×10^{0} [c]
2-Hexanone	100 [c]	1.75×10^{-3} [n]	8.08×10^{-2} [g,o]	9.80×10^{-6} [g]	1.35×10^{-2} [n]	1.80×10^{4} [c]
Isopropyl Benzene	120 [c]	1.20×10^{0} [c]	7.50×10^{-2} [e]	7.10×10^{-6} [e]	2.20×10^{2} [e]	6.10×10^{1} [c]
4-Isopropyltoluene	134 [k]	1.78×10^{-2} [k]	6.53×10^{-2} [k]	NA	2.23×10^{3} [k,j]	2.40×10^{1} [k]
Methylene Chloride	85 [c]	2.20×10^{-3} [c]	1.01×10^{-1} [d,e]	1.17×10^{-5} [d,e]	1.17×10^{1} [d]	1.30×10^{4} [d,c]
4-Methyl-2-Pentanone	100 [c]	1.40×10^{-4} [c,e]	7.50×10^{-2} [e]	7.80×10^{-6} [e]	1.34×10^{2} [e]	1.90×10^{4} [c,e]
Methyl tert-Butyl Ether	88 [h]	5.77×10^{-4} [h]	7.92×10^{-2} [h]	9.41×10^{-5} [h]	1.20×10^{1} [i]	4.80×10^{4} [a]
Naphthalene	128 [c]	4.80×10^{-4} [c]	5.90×10^{-2} [d]	7.50×10^{-6} [d,e]	2.00×10^{3} [d]	3.10×10^{1} [d,c,
Phenanthrene	178 [c]	2.30×10^{-5} [c]	3.33×10^{-2} [g]	7.47×10^{-6} [g]	1.40×10^{4} [g]	1.20×10^{0} [c]
n-Propylbenzene	120 [f]	1.03×10^{-2} [f]	7.50×10^{-2} [b]	NA	7.24×10^{2} [f]	6.50×10^{1} [f]
Pyrene**	202 [c]	1.10×10^{-5} [c]	2.72×10^{-2} [d]	7.24×10^{-6} [d]	1.05×10^{5} [d]	1.40×10^{-1} [c]
Styrene	104 [c]	2.70×10^{-3} [c]	7.10×10^{-2} [d]	8.00×10^{-6} [d]	7.76×10^{2} [d]	3.10×10^{2} [c]
1,1,1,2-Tetrachloroethane	168 [c]	2.40×10^{-3} [c]	7.10×10^{-2} [e]	7.90×10^{-6} [e]	7.90×10^{1} [e]	1.10×10^{3} [c]
Tetrachloroethene	166 [c]	1.80×10^{-2} [c]	7.20×10^{-2} [d,e]	8.20×10^{-6} [d,e]	1.55×10^{2} [d]	2.00×10^{2} [d,c]
Toluene	92 [c]	6.60×10^{-3} [c]	8.70×10^{-2} [d]	8.60×10^{-6} [d,e]	1.82×10^{2} [d]	5.26×10^{2} [d]
1,1,1-Trichloroethane	133 [c]	1.70×10^{-2} [c]	7.80×10^{-2} [d]	8.80×10^{-6} [d,e]	1.10×10^{2} [d]	1.33×10^{3} [d]
Trichloroethene	131 [c]	1.00×10^{-2} [c]	7.90×10^{-2} [d]	9.10×10^{-6} [d,e]	1.66×10^{2} [d]	1.10×10^{3} [d,c]

Table 5-10 (Page 2 of 2)
Physical/Chemical Properties for Volatile Organic Compounds*

Chemical	Molecular Weight (g/mole)	Henry's Law Constant (atm-m^3/mole)	Diffusivity in Air (cm^2/s)	Diffusivity in Water (cm^2/s)	Organic Carbon Partition Coefficient (L/kg)	Solubility (mg/L)
1,2,4-Trimethylbenzene	120 [a]	5.70×10^{-3} [a]	7.50×10^{-2} [b]	NA	3.72×10^{3} [a]	2.55×10^{-1} [a]
1,3,5-Trimethylbenzene	120 [f]	7.71×10^{-3} [f]	7.50×10^{-2} [b]	NA	8.19×10^{2} [f]	5.00×10^{1} [f]
Vinyl Acetate	86 [c]	5.10×10^{-4} [c]	8.50×10^{-2} [d]	9.20×10^{-6} [d]	5.25×10^{0} [d]	2.00×10^{4} [c]
Vinyl Chloride	63 [c]	2.70×10^{-2} [c]	1.06×10^{-1} [d]	1.23×10^{-5} [d]	1.86×10^{1} [d]	2.76×10^{3} [d]
Xylenes (Total)	106 [c]	6.73×10^{-3} [m]	7.80×10^{-2} [m]	8.75×10^{-6} [m]	3.86×10^{2} [m]	1.75×10^{2} [m]

cm^2/s denotes square centimeters per second

L/kg denotes liters per kilogram

mg/L denotes milligrams per liter

g denotes grams

atm-m^3/mol denotes

NA denotes Not Available

** Based on EPA (1991) criteria for a Henry's Law constant greater than 10^{-5} atm-m^3/mole and a molecular weight of less than 200 g/mol.*

*** Listed as volatile organic compounds by the EPA (2000).*

a Montgomery, J. H., 1991, Groundwater Chemicals Desk Reference, Volume 2, Lewis Publishers, Chelsea, Minnesota.

b Approximate average developed by ENVIRON for certain alkylated benzene compounds.

c U.S. Environmental Protection Agency (EPA), June 1996a, Superfund Chemical Data Matrix, Washington, D.C.

d U.S. Environmental Protection Agency (EPA), July 1996b, Soil Screening Guidance, Washington, D.C.

e U.S. Environmental Protection Agency (EPA), November 1, 2000, Region 9 Preliminary Remediation Goals (PRGs) 2000, Physical Chemical Properties Table.

f Mackay, D., W.Y. Shiu, and K.C. Ma., 1992, Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Volume 1, Monoaromatic Hydrocarbons, Chlorobenzenes, and PCBs, Lewis Publishers, Chelsea, Minnesota.

g U.S. Environmental Protection Agency (EPA), 1987, Hazardous Waste Treatment Storage and Disposal Facility (TSDF) - Air Emission Models, Office of Air and Radiation, Emission Standards Division, EPA-450/3-87-026, Research Triangle Park, North Carolina

h RBCA Chemical Database of Physical Property Data

i Emergency Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites, ASTM, ES, 38-94

j Calculated using log K_{oc} = 0.7919 log K_{ow} + 0.0784, from reference f.

k STEPP, 1996, Software to Estimate Physical Properties, Database developed by CenCITT, a EPA Center.

l Assumed the same as the value for tert-Butylbenzene.

m In the absence of data, values for mixtures of isomers were estimated by averaging the individual isomers.

n Montgomery, J. H. and Welkom, L.M. 1990. Groundwater Chemicals Desk Reference. Chelsea, MI: Lewis Publishers.

o In the absence of data specific to this chemical, data for a surrogate were used.
For 4-Chlorotoluene, some data for 2-Chlorotoluene was used.
For 2-Hexanone, some data for 2-Butanone was used.

p Syracuse Research Corporation. Available on the Internet, http://www.syrres.com

gas-to-air transfer coefficient. Hence, this release also models a constant groundwater concentration migrating into overlying soil, yielding a flux that is then input into an air dispersion model – the indoor air or trench case, as appropriate.

As mentioned already, transfer factors from groundwater-to-air are conservatively calculated assuming steady state conditions (i.e., when the chemical flux has become constant) even through for some chemicals it may take hundreds of years to attain steady state. The fact that groundwater and soil gas concentrations are poorly correlated (Appendix B) is indicative of a situation where steady-state conditions do not exist.

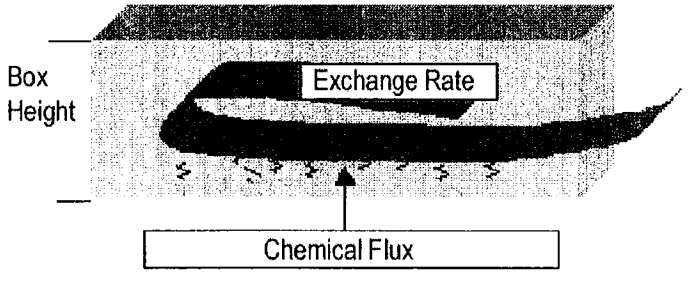
Further detail about the VLEACH model is presented in Appendix C, Attachment 1.

5.6.1.2 Air Concentrations

Box models were used to estimate indoor and trench air concentrations based on the predicted chemical flux from soil gas and groundwater. The following subsection discusses the estimation of indoor and trench air concentrations. Note that the Johnson and Ettinger spreadsheet model (EPA, 2000a) used for the CalEPA methodology has an indoor air box model built into it that is discussed in Section 5.6.2.

Indoor Air Concentrations. For the residential scenario, indoor air concentrations were modeled as the result of volatile chemicals migrating from soil gas into air within a home, as shown below.

Box Model to Evaluate Ambient and Indoor Air Concentrations



These concentrations were estimated using the following equation that represents an indoor box model, which assumes complete mixing within a ventilated building:

$$C_i^{indoor} = \frac{F_i \; f \; R}{X_{rate} H_b}$$

Where:

C_i^{indoor} = Indoor concentration of chemical i (mg/m^3)
F_i = Emission Flux of chemical i (mg/m^2-second [s])
f = Slab attenuation factor (unitless)
R = Fraction of building above the area of concern (unitless)
X_{rate} = Outdoor air exchange rate (1/s)
H_b = Ceiling height of building (meter [m])

In this assessment, the characteristics of the box come from basic assumptions about a residence. For example, an outdoor air exchange rate of 0.45/hour is assumed for a residential building. This is the default value used in the Johnson and Ettinger spreadsheet (EPA, 2000a). It is equivalent to the geometric mean of houses reported by Koontz and Rector (1995) and the average reported by Parker et al. (1990). The ceiling height within the building is taken to be a default value of 8 feet (2.4 meters), the typical height of ceilings in residential buildings not including attic or second story air space that may also contribute to mixing height (ASHRAE, 1997).

The attenuation of chemical flux through the concrete slab of residential buildings, or slab attenuation factor, is set at 10 percent. This means that ten percent of the flux from VLEACH is allowed through the floor of the building. Homes that are built with an air space between the soil and the breathing space would generally have a lower slab attenuation factor (i.e., higher attenuation) than those without it. Since the existing housing complexes on OU-5 have crawl spaces, the chosen slab attenuation factor is likely to yield conservative risk estimates for current residents. For this scenario, the residence is assumed to be directly over impacted groundwater. The indoor air parameters are summarized in Table 5-11, "Input Parameters for Emission Modeling" and the dispersion modeling parameters are summarized in Table 5-12, "Input Parameters for Air Dispersion Modeling." Table 5-13, "Estimated Soil Gas-to-Air Transfer Coefficients" presents the soil gas-to-air transfer factors for the residential scenario. An example calculation is presented in Appendix C, Attachment 1.

Trench Air Concentration. Volatile organic compounds migrating from either soil gas or shallow groundwater into trench air were predicted in this assessment for the construction worker

Table 5-11
Input Parameters for Emission Modeling

Parameter	Unit	VLEACH	Johnson & Ettinger
Effective Soil Porosity [a]	--	0.38	0.38
Soil Dry Bulk Density [a]	g/cc	1.63	1.63
Volumetric Water Content of Soil [a]	cc water/cc soil	0.23	0.23
Soil Organic Carbon Content [a]	--	0.0057	NA
Soil Type (Used to estimate soil vapor permeability)[a]	--	NA	Sandy Loam
Average Soil Temperature[c]	C	NA	15
Depth to Ground Water[a]	feet	8	NA
Surface Area Weighted Depth to Ground Water (trench)[b]	feet	4.6	NA
Ground Water Recharge Rate[c]	feet/year	0	NA
Normalized Concentration of Chemicals in Groundwater	mg/L	1	NA
Normalized Concentration of Chemicals in Soil	mg/kg	1	NA

NA denotes Not Applicable
cc denotes cubic centimeter
g denotes grams
kg denotes kilogram
L denotes liter
mg denotes milligram

[a] *Site specific data*

[b] *Weighted DTW = (Ab/Atot)(8 ft - 3 ft) + (Asides/Atot)(8 ft - 5ft/2)*

[c] *Conservative default assumption*

Table 5-12
Input Parameters for Air Dispersion Modeling

Parameter	Unit	Indoor Air (VLEACH)	Outdoor Trench (VLEACH)	Indoor Air (Johnson & Ettinger)
Height[a,b,e]	feet	8	5	16
Length[b,e]	feet	NA	20	32
Width[b,e]	feet	NA	8	32
Slab Attenuation Factor for Future Residential Buildings	-	0.1	NA	NA
Indoor Air Exchange Rate[a,e]	1/hour	0.45	NA	0.45
Wind Speed[c]	feet/second	NA	3.28	NA
Fraction of Building Above Contaminated Area[d]	-	1	NA	NA

NA denotes Not Applicable

[a] *Based on information from ASHRAE guidance (ASHRAE 1997).*

[b] *Outdoor trench dimensions based on professional judgement.*

[c] *EPA, 1995 (professional judgement, lowest of SCREEN).*

[d] *Most conservative assumption.*

e *Johnson & Ettinger Spreadsheet default (EPA, 2000)*

American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. (ASHRAE), 1997, 1997 ASHRAE Handbook - Fundamentals, *Atlanta, Georgia.*

U.S. Environmental Protection Agency (EPA), September 1995, SCREEN3 Model User's Guide, *Office of Air Quality Planning and Standards, EPA-450-4-92-006, Research Triangle Park, North Carolina.*

U.S. Environmental Protection Agency (EPA), December 2000, User's Guide for Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings (Revised).

Table 5-13
Estimated Soil Gas-to-Air Transfer Coefficients

Chemical	Indoor Resident[a] (mg/m^3)/(ug/m^3)	Outdoor Trench Construction Worker[a] (mg/m^3)/(ug/m^3)
Acetone	$8.30x10^{-8}$	$1.79x10^{-8}$
Benzene	$5.88x10^{-8}$	$1.27x10^{-8}$
2-Butanone	$5.97x10^{-8}$	$1.29x10^{-8}$
Chlorobenzene	$4.89x10^{-8}$	$1.05x10^{-8}$
Chloroethane	$6.69x10^{-8}$	$1.44x10^{-8}$
Chloroform	$6.96x10^{-8}$	$1.50x10^{-8}$
1,1-Dichloroethane	$4.96x10^{-8}$	$1.07x10^{-8}$
1,1-Dichloroethene	$6.01x10^{-8}$	$1.30x10^{-8}$
cis-1,2-Dichloroethene	$4.93x10^{-8}$	$1.06x10^{-8}$
Ethylbenzene	$5.02x10^{-8}$	$1.08x10^{-8}$
2-Hexanone	$5.40x10^{-8}$	$1.16x10^{-8}$
4-Methyl-2-Pentanone	$5.01x10^{-8}$	$1.08x10^{-8}$
Methyl tert-Butyl Ether	$5.29x10^{-8}$	$1.14x10^{-8}$
Naphthalene	$4.25x10^{-8}$	$8.62x10^{-9}$
Styrene	$4.74x10^{-8}$	$1.02x10^{-8}$
Tetrachloroethene	$4.81x10^{-8}$	$1.04x10^{-8}$
Toluene	$5.82x10^{-8}$	$1.26x10^{-8}$
1,1,1-Trichloroethane	$5.21x10^{-8}$	$1.13x10^{-8}$
Trichloroethene	$5.28x10^{-8}$	$1.14x10^{-8}$
Vinyl Acetate	$5.68x10^{-8}$	$8.77x10^{-10}$
Xylenes (Total)	$5.22x10^{-8}$	$1.47x10^{-8}$

[a] *Based on groundwater as chemical source and contamination at 2 feet bgs*
(mg/m^3)/(ug/m^3) denotes milligrams per cubic meter/micrograms per cubic meter

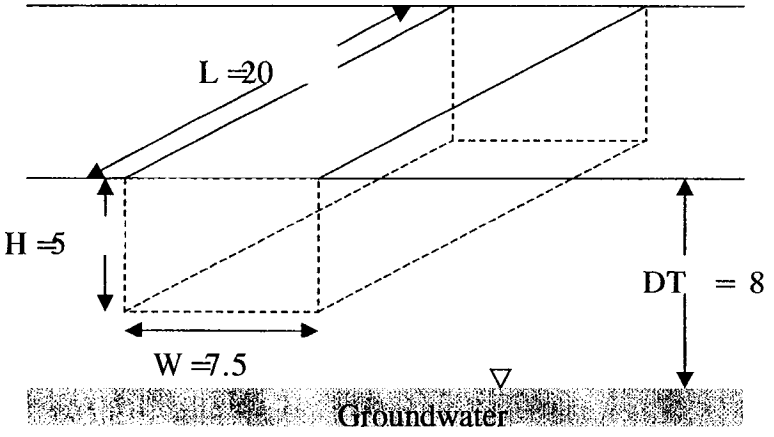
scenario. A modified box model was used for modeling dispersion in a trench because of re-circulation that occurs as the result of turbulence generated by surface winds traveling over the trench. This trench scenario is analogous to air concentrations within a street canyon if the length of the trench is sufficiently longer than the width. Therefore, studies on air concentrations within street canyons were used to calculate the average concentration of the air within the trench using the following equation (Cermak, et al., 1974 and Kastner-Klein, et al., 1999):

Where:

C_i^{trench} = Ambient concentration of chemical i in the trench (mg/m^3);
C_* = Dimensionless value, = 25;
F_s = Emission flux of chemical i from the soil (mg/m^2-s);
A_s = Surface area of the trench which is contaminated soil (m^2)
= (WL+2HW+2HL);
W = Width of the trench (meters [m]);
L = Length of the trench (m);
H = Height of the trench (m); and
u = Average free-stream wind speed (meters per second).

In the above equation, the dimensionless value C_* was empirically developed through laboratory and field studies as described in Cermak, et al. (1974) and Kastner-Klein, et al. (1999). This value of C_* is appropriate for determining the average concentration in the middle of the trench assuming the length of the trench is sufficiently longer than the width. Cermak, et al. (1974) provides values for C_* for the middle and both edges of the center cross-section of the length of both a model street canyon and an actual street canyon. The values for C_* of three different height levels of the middle and widthwise edges of the street canyon average to approximately 25. This value for C_* is similar to that found in laboratory studies by Kastner-Klein, et al. (1999) at the lee wall of an upwind building (i.e., inside the trench on the upwind side) with no moving traffic in the street canyon.

The average free-stream wind speed is 3.28 feet per second, similar to the outdoor air model (EPA, 1995). All parameters used in the trench modeling are summarized in Table 5-12.



For this assessment, a trench that is 20 feet (6 meters) long, approximately five feet (1.5 meters) high and approximately 7.5 feet (2.3 meters) wide was evaluated. The concentration in the trench was determined by conservatively assuming that vapors emanate from the bottom and all four sides of the trench. Vapors emanate from different heights on the sides of the trench with different fluxes due to the different depth to groundwater at the different heights. To account for this effect, a surface-area-weighted, average depth to groundwater was used in the VLEACH modeling, calculated as follows:

$$\text{Surface area weighted DTW} = \left(\frac{WL}{A_s}\right)(DTW - H) + \left(\frac{2HW + 2HL}{A_s}\right)\left(DTW - \frac{H}{2}\right)$$

VLEACH was then run using the surface area weighted depth to water to arrive at the flux, F_s, used in evaluating the trench air concentration.

Table 5-13 presents the soil gas-to-air transfer factors and Table 5-14, "Estimated Groundwater-to-Air Transfer Coefficients" presents the groundwater-to-air transfer factors for the trench scenario.

5.6.2 Migration of Volatile Chemicals – Johnson and Ettinger

For the CalEPA methodology, modeling of the transport of volatile chemicals from soil gas to residential indoor air was based on the mathematical model developed by Johnson and Ettinger (EPA, 2000a). This model provides an estimate of the flux of a chemical into a building resulting from the one-dimensional transport by diffusion and convection through the vadose

Table 5-14
Estimated Groundwater-to-Air Transfer Coefficients

Chemical	Outdoor Trench Construction Worker $(mg/m^3)/(mg/L)$
Acenaphthene	4.05×10^{-6}
Acetone	1.18×10^{-5}
Anthracene	3.98×10^{-7}
Benzene	1.21×10^{-3}
Bromodichloromethane	1.17×10^{-4}
2-Butanone	1.24×10^{-5}
n-Butylbenzene	2.42×10^{-3}
sec-Butylbenzene	3.44×10^{-3}
Carbon Disulfide	7.77×10^{-3}
Chlorobenzene	6.67×10^{-4}
Chloroethane	2.71×10^{-3}
Chloroform	9.38×10^{-4}
4-Chlorotoluene	6.06×10^{-4}
Dibromochloromethane	3.77×10^{-5}
1,2-Dichlorobenzene	3.23×10^{-4}
Dichlorodifluoromethane	6.70×10^{-2}
1,1-Dichloroethane	1.02×10^{-3}
1,2-Dichloroethane	2.51×10^{-4}
1,1-Dichloroethene	5.80×10^{-3}
cis-1,2-Dichloroethene	7.39×10^{-4}
trans-1,2-Dichloroethene	1.63×10^{-3}
Ethylbenzene	1.46×10^{-3}
Fluoranthene	7.01×10^{-8}
Fluorene	6.13×10^{-7}
2-Hexanone	3.48×10^{-4}
Isopropyl Benzene	2.21×10^{-1}
4-Isopropyltoluene	2.86×10^{-3}
Methylene Chloride	5.46×10^{-4}
4-Methyl-2-Pentanone	2.59×10^{-5}
Methyl tert-Butyl Ether	1.14×10^{-4}
Naphthalene	6.73×10^{-5}
Phenanthrene	1.47×10^{-7}
n-Propylbenzene	1.89×10^{-3}
Pyrene	7.05×10^{-7}
Styrene	4.82×10^{-4}
1,1,1,2-Tetrachloroethane	7.02×10^{-5}
Tetrachloroethene	3.26×10^{-3}
Toluene	1.42×10^{-3}
1,1,1-Trichloroethane	3.31×10^{-3}
Trichloroethene	2.01×10^{-3}
1,2,4-Trimethylbenzene	1.05×10^{-3}
1,3,5-Trimethylbenzene	1.42×10^{-3}
Vinyl Acetate	1.07×10^{-4}
Vinyl Chloride	7.08×10^{-3}
Xylenes (Total)	1.30×10^{-3}

$(mg/m^3)/(mg/L)$ denotes milligrams per cubic meter/milligrams per liter

zone and building floor slab. Like VLEACH, indoor air concentrations are calculated from the flux assuming a simple dilution process. Figure 5-2 shows flow charts comparing the Johnson and Ettinger and VLEACH modeling approaches. The main difference between the approaches is how attenuation of vapor flux across the building foundation is represented. VLEACH uses a simple slab attenuation factor, while the Johnson and Ettinger model represents the processes of advection and diffusion across the foundation using simple analytical solutions to the physical equations.

U.S. Environmental Protection Agency implemented this model as a spreadsheet, including the equations described by Johnson and Ettinger (2000a). The spreadsheet model provides default assumptions, chemical properties, and toxicity criteria to allow the direct calculation of either risks or risk-based concentrations for a residential adult. In contrast to the multiple steps involved in the VLEACH approach, the spreadsheet model directly outputs the risk characterization values given the measured soil gas concentrations (Figure 5-2). For this assessment, Version 2.3 of the EPA, Johnson and Ettinger model was used. Toxicity values were updated to represent the CalEPA hierarchy of sources discussed in Section 5.8.3. When available, site-specific parameters were used. In the absence of such data, default parameters or conservative estimates were used. To the degree that there was consistency of inputs between VLEACH and the Johnson and Ettinger models, the parameter values used for those inputs were also maintained to be consistent. The input files used for the Johnson and Ettinger model are included in Appendix C, Attachment 2. These files include physical/chemical parameters and modeling parameters.

5.6.3 Windblown Dust

It is assumed that residents may be exposed to airborne particulates on a daily basis under regular site conditions. Based on EPA screening guidelines, a particulate emission factor (PEF) of 1.316×10^9 m^3/kg was used to estimate airborne concentrations of a chemical from the corresponding soil concentration (EPA, 2000a). This particulate emission factor corresponds to a soil-to-air correlation factor of 7.6×10^{-10} $(mg/m^3)/(mg/kg)$ of the soil concentration for each chemical.

For construction workers, a particulate emission factor of 1.44×10^6 m^3/kg was used based on San Francisco Regional Water Quality Control Boards guidance. This particulate emission factor corresponds to a soil-to-air correlation factor of 6.95×10^{-7} $(mg/m^3)/(mg/kg)$ of the soil concentration for each chemical (SFRWQCB, 2000).

As part of the estimation of the potential exposure via inhalation of dust, it is assumed that the inhaled dust has the same chemical composition as the soil at the site. This is a conservative assumption because not all of the dust in the air at the site will have originated from surface soil at the site.

5.7 Exposure Point Concentrations

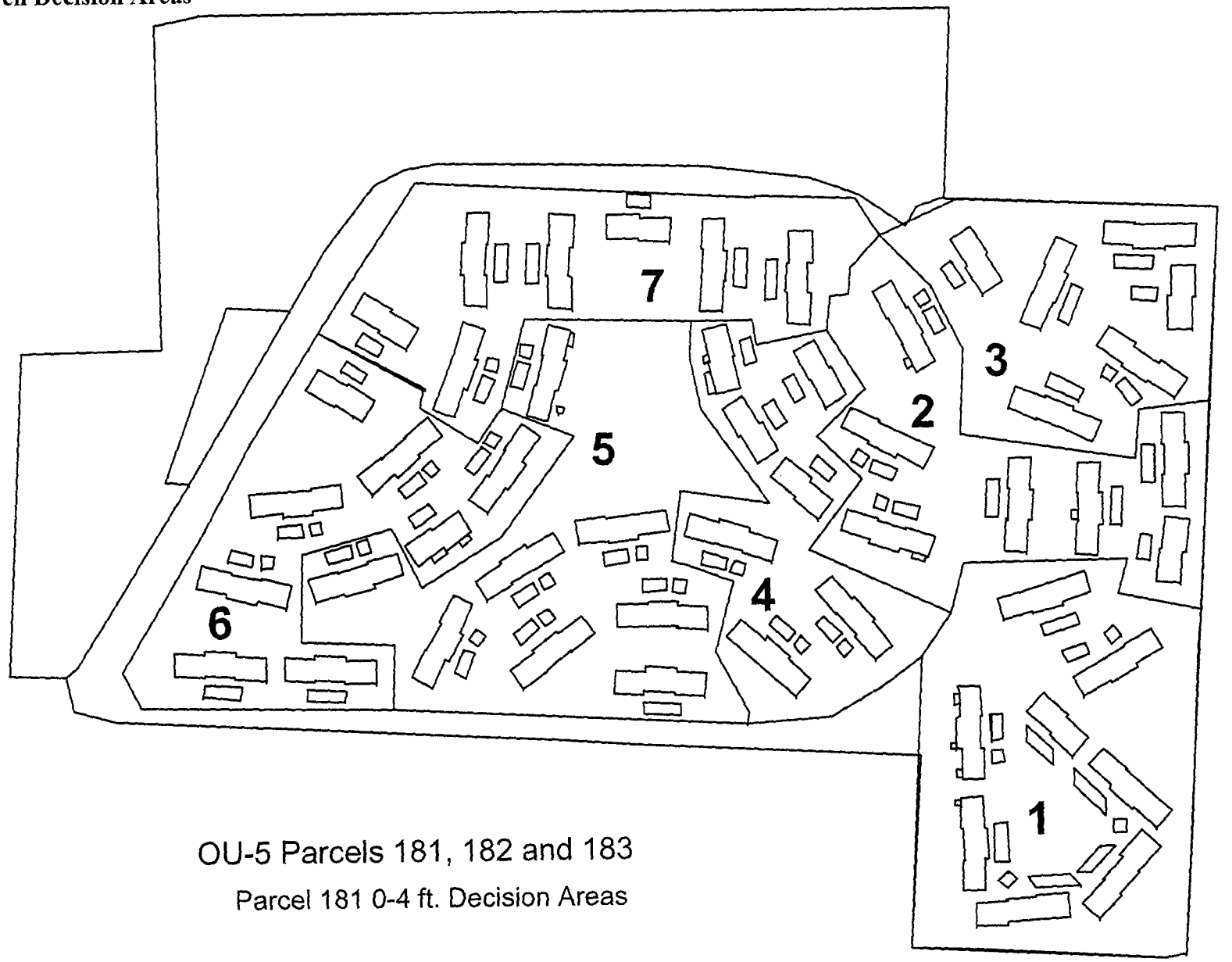
To support the evaluation of human health risk, soil BaP-equivalent concentrations calculated using EPA toxicity equivalency factors (TEF) were used to identify risk assessment decision areas. As described in the RI Work Plan (Neptune and Company, 2001) and summarized in Section 3.4 of this RI Report, decision areas were derived from an evaluation of the spatial distribution of BaP-equivalent concentrations in the 0 to 0.5 foot bgs, 0 to 2 foot bgs, and 0 to 4 foot bgs depth intervals. These areas represent portions of Parcel 181 where BaP-equivalent concentration values are relatively similar.

Spatial plots of the EPA BaP-equivalent concentration soil concentration data were used to visually delineate decision areas. The mean and variance of the BaP-equivalent concentrations within each decision area was then calculated to make sure that the decision areas were successful in minimizing the variance and therefore maximizing the representativeness of average BaP-equivalent concentrations for the risk assessment calculations. Details and supporting graphics for the process of identifying decision areas are provided in Appendix B.

The final result of the post stratification exercise was to divide Parcel 181 into seven decision areas (Figure 5-4 and Appendix B, Figure B-3) which groups housing areas in such a way as to minimize the variance in BaP-equivalent concentrations within 4 feet of the ground surface. During this process, the Navy and the regulatory authority reached an agreement to remove soil to a depth of 2 feet over a large portion of Parcel 181 where concentrations appeared highest (see Figure 2-5). Decision areas 4, 5, and 7 comprise the area slated for the removal action (Figure 5-4). Results from soil samples in each decision area will be used to calculate the mean and 95 percent upper confidence limit (UCL) on the mean in each decision area for various depth intervals to support the quantitative assessment of risk to current and future residents of OU-5.

Having completed the post stratification of the site into decision areas based on EPA BaP-equivalent concentration distributions in the top 4 feet, the distribution of EPA BaP-equivalent concentrations in the 4 to 8 foot depth interval was evaluated in more detail. Benzo(a)pyrene-equivalent concentrations for the 4 to 8 foot depth interval were evaluated separately because fewer samples were taken in this depth interval and a different pattern of BaP-equivalent concentrations was evident. The concentrations of PAHs are generally higher

Figure 5-4
Seven Decision Areas



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Final

below 4 feet in the northern and western portions of OU-5. Figure 5-5 and Appendix B, Figure B-6, shows the separation of the BaP-equivalent concentrations in the 4 to 8 foot interval into two areas: one with generally higher concentrations in the northern half of Parcel 181, and one with generally lower concentrations in the southern half of Parcel 181.

The calculation of EPA BaP-equivalent concentrations for each soil sample was discussed in Section 4.1 of this report as these BaP-equivalent concentrations were employed for the evaluation of the nature and extent of carcinogenic PAHs in Parcel 181 soils. Based upon comments received from California regulatory authorities, additional BaP-equivalent concentrations have been calculated using cancer slope factors and TEF values recommended by CalEPA. California EPA BaP-equivalent concentrations were calculated for the following PAHs, with the CalEPA TEF value for each PAH noted in parentheses:

- Benz(a)anthracene (0.1)
- Benzo(a)pyrene (1.0)
- Benzo(b)fluoranthene (0.1)
- Benzo(k)fluoranthene (0.1)
- Chrysene (0.01)
- Dibenz(a,h)anthracene (4.1/12)
- Indeno(1,2,3-cd)pyrene (0.1)

The TEF value for dibenz(a,h)anthracene requires some explanation as it is actually based on the ratio of two slope factors rather than a TEF value. Unlike the EPA, CalEPA publishes separate oral and inhalation slope factors for dibenz(a,h)anthracene rather than a factor-of-ten TEF that is related to the slope factor of BaP. The TEF used for dibenz(a,h)anthracene in this evaluation is the CalEPA oral slope factor for dibenz(a,h)anthracene divided by the CalEPA oral slope factor for BaP. The ratio of the oral slope factors rather than the inhalation slope factors was used because the inhalation exposure route is a negligible contributor to risks associated with soil-based exposure to PAHs. Like EPA BaP-equivalent values, the CalEPA BaP-equivalent is calculated for each soil sample as the sum of the product of PAH soil concentration and TEF value for the seven carcinogenic PAHs.

To generate soil EPCs for the risk assessment, the 95 percent UCL on the arithmetic average concentration was calculated (EPA, 1989). Calculations of 95 percent UCLs depend on the underlying distribution of the data in each decision area. Goodness-of-fit tests as well as visual examination of the data was used to determine if the data fit a continuous mathematical distribution such as the normal or log normal distribution. Appendix B presents a more detailed explanation of the types of plots and tests used to perform these analyses. Using the results of

these statistical tests and visual plots, the distribution of EPA and CalEPA BaP-equivalent concentrations and most metal concentrations were best approximated by a log normal distribution. In cases where the log normal 95 percent UCL was much higher than the maximum observed (detected) value, the maximum detected value was used as the EPC. The following equation was utilized to calculate the 95 percent UCL, assuming log normality:

$$UCL_{1-\alpha} = exp\left(\bar{y} + 0.5 s_y^2 + \frac{s_y H_{1-\alpha}}{\sqrt{n-1}}\right)$$

Where:

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

$$s_y^2 = \frac{1}{n-1}\sum_{i=1}^{n} (y_i - \bar{y})^2$$

n = *number of values*

and

$y_i = \ln x_i$

$H_{1-\alpha}$ = *from Tables A10 – A13 (Gilbert, 1987)*

In this equation, the log of the individual values (X_i) is first taken and these logged values denoted as Y_i. The mean and variance of the Y values is then calculated and used in the first formula, along with an H statistic from a lookup table (corresponding to an alpha 0.05 or a 95th confidence level) to generate the 95 percent UCL on the logged mean. Table 5-15, "Exposure Point Concentrations for Benzo(a)pyrene-Equivalents in Soil – Current and Future Residents – EPA Methodology" presents the BaP-equivalent concentration EPCs for each of the decision areas, by depth strata, down to 8 feet. Table 5-15 provides these results based on EPA methodology and Table 5-16, "Exposure Point Concentrations for Benzo(a)pyrene-Equivalents in Soil – Current and Future Residents – CalEPA Methodology" provides these results based on CalEPA methodology. Additional summary statistics associated with the EPCs are presented in Appendix B. Table 5-17, "Exposure Point Concentrations for Individual Polynuclear Aromatic Hydrocarbons in Soil (milligrams per kilogram) – Current and Future Residents" presents the EPCs for individual PAHs by decision area.

Two decisions were made during the planning stages of the RI that affect the usability of soil EPCs for the risk assessment. These decisions were that fewer samples would be collected from the 4 to 8 foot depth interval than from the upper three depth intervals and a more limited set of samples across OU-5 would be analyzed for metals. The decision to collect fewer samples in the deepest depth interval was made because chronic exposure to soils at this depth is unlikely and

Figure 5-5
Division of Northern and Southern Exposure Area

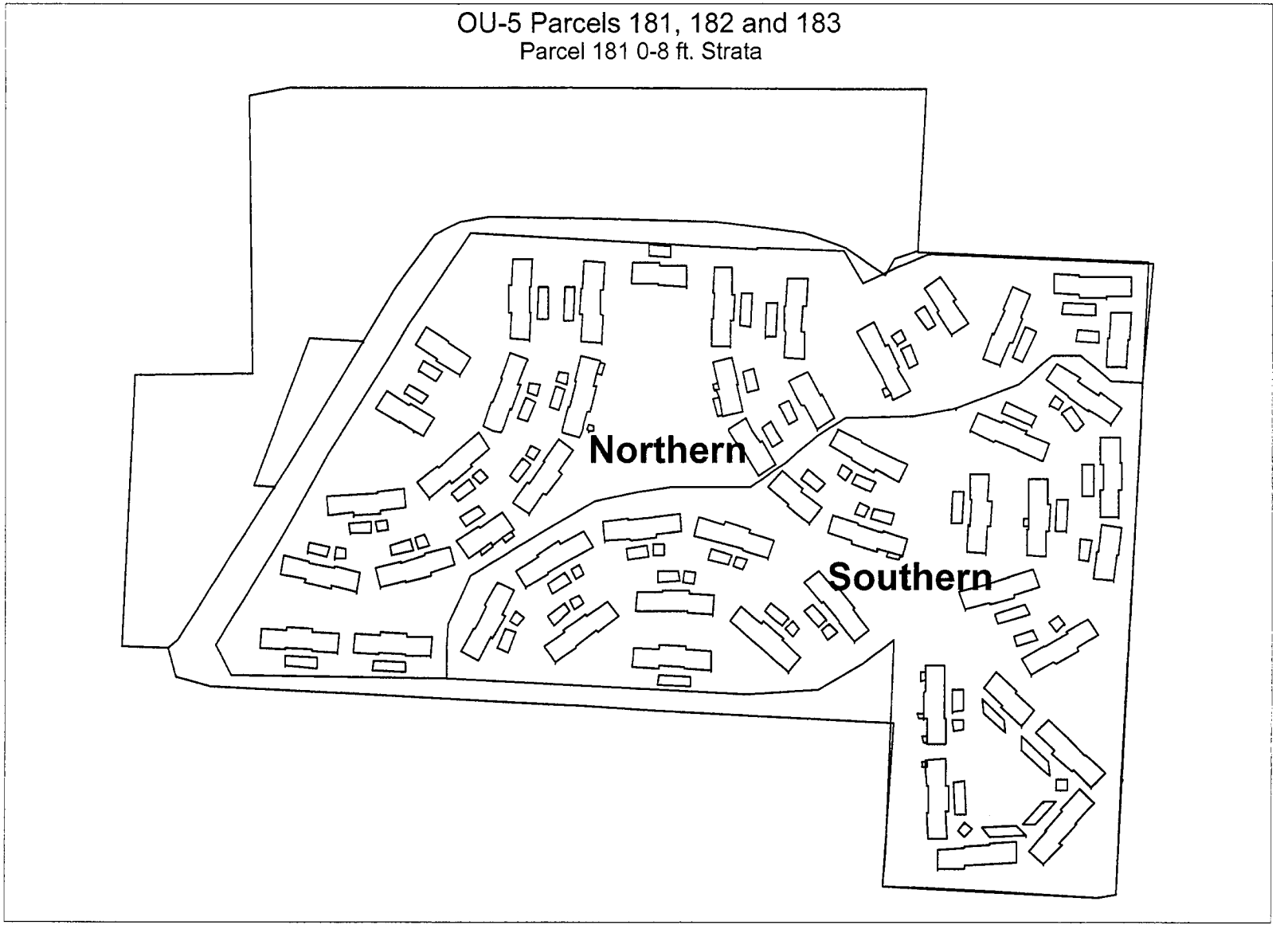

Table 5-15
Exposure Point Concentrations for Benzo(a)Pyrene-Equivalents in Soil - Current and Future Residents - EPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
1	0-0.5	1.04
1	0-2.0	0.477
1	0-4.0	0.488
1	0-8.0	0.780
2	0-0.5	2.84
2	0-2.0	1.98
2	0-4.0	4.54
2	0-8.0	9.62
3	0-0.5	1.15
3	0-2.0	0.793
3	0-4.0	0.737
3	0-8.0	11.78
4	0-0.5	3.04
4	0-2.0	3.03
4	0-4.0	3.85
4	0-8.0	5.19
5	0-0.5	2.97
5	0-2.0	3.47
5	0-4.0	4.22
5	0-8.0	2.75
6	0-0.5	1.33
6	0-2.0	1.87
6	0-4.0	3.02
6	0-8.0	15.3
7	0-0.5	9.63
7	0-2.0	7.18
7	0-4.0	6.49
7	0-8.0	77.3

mg/kg denotes milligrams per kilogram
bgs denotes below ground surface

Table 5-16
Exposure Point Concentrations for Benzo(a)Pyrene Equivalents in Soil - Current and Future Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
1	0-0.5	1.01
1	0-2.0	0.438
1	0-4.0	0.458
1	0-8.0	0.606
2	0-0.5	2.35
2	0-2.0	1.71
2	0-4.0	4.20
2	0-8.0	8.11
3	0-0.5	1.20
3	0-2.0	0.838
3	0-4.0	0.731
3	0-8.0	11.3
4	0-0.5	2.57
4	0-2.0	2.63
4	0-4.0	3.24
4	0-8.0	4.36
5	0-0.5	2.47
5	0-2.0	2.92
5	0-4.0	3.58
5	0-8.0	2.40
6	0-0.5	1.20
6	0-2.0	1.64
6	0-4.0	2.63
6	0-8.0	11.9
7	0-0.5	7.26
7	0-2.0	5.98
7	0-4.0	5.67
7	0-8.0	74.8

mg/kg denotes milligrams per kilogram
bgs denotes below ground surface

Table 5-17 (Page 1 of 2)
Exposure Point Concentrations for Individual Polynuclear Aromatic Hydrocarbons in Soil (milligrams per kilogram) - Current and Future Residents

Chemical	Depth Interval (feet bgs)	Area 1	2	3	4	5	6	7
Acenapthene	0-0.5	0.019	0.130	0.222	1.41	0.076	0.031	5.98
	0-2.0	0.015	0.133	0.027	0.038	0.147	0.067	2.20
	0-4.0	0.014	0.368	0.027	0.038	0.389	0.201	1.39
	0-8.0	0.014	0.057	0.624	1.17	0.065	0.190	4.55
Acenapthylene	0-0.5	0.061	0.668	0.120	1.10	0.320	0.082	0.870
	0-2.0	0.065	0.355	0.067	0.493	0.691	0.210	0.630
	0-4.0	0.123	0.470	0.053	0.575	0.720	0.389	0.959
	0-8.0	0.070	0.858	0.055	0.793	0.343	1.77	35.0
Athracene	0-0.5	0.055	0.108	0.110	0.219	0.290	0.110	1.94
	0-2.0	0.034	0.113	0.097	0.263	0.459	0.162	1.65
	0-4.0	0.031	0.321	0.115	0.329	0.420	0.269	1.51
	0-8.0	0.037	2.81	0.974	0.962	0.276	2.72	45.0
Benz(a)anthracene	0-0.5	0.333	0.922	0.719	0.816	0.973	0.453	2.90
	0-2.0	0.162	0.715	0.440	0.899	1.18	0.631	2.45
	0-4.0	0.153	1.69	0.391	1.03	1.26	0.863	2.19
	0-8.0	0.210	3.88	6.03	1.78	1.00	5.62	35.4
Benzo(a)pyrene	0-0.5	0.752	1.69	1.05	2.00	1.75	0.916	4.80
	0-2.0	0.335	1.27	0.693	1.97	2.07	1.19	4.21
	0-4.0	0.364	3.29	0.594	2.41	2.57	1.91	4.18
	0-8.0	0.403	6.05	8.54	3.31	1.78	8.81	57.6
Benzo(b)flouranthene	0-0.5	0.506	1.43	1.50	1.07	1.24	0.743	3.20
	0-2.0	0.257	1.04	0.773	1.30	1.55	0.978	2.93
	0-4.0	0.272	2.77	0.812	1.48	1.93	1.52	2.90
	0-8.0	0.356	42.8	8.54	1.92	1.28	6.25	39.0
Benzo(g,h,i)perylene	0-0.5	0.704	1.25	0.621	1.72	1.84	0.974	4.39
	0-2.0	0.247	1.11	0.521	1.85	2.11	1.37	4.50
	0-4.0	0.259	2.77	0.416	2.17	2.73	2.14	4.53
	0-8.0	0.402	2.86	4.44	2.89	1.54	8.42	40.9
Benzo(k)fluoranthene	0-0.5	0.235	0.424	0.160	0.535	0.573	0.290	1.47
	0-2.0	0.130	0.415	0.100	0.592	0.661	0.451	1.34
	0-4.0	0.122	0.804	0.144	0.678	0.755	0.614	1.20
	0-8.0	0.177	1.17	4.07	1.04	0.457	3.46	18.8
Chrysene	0-0.5	0.339	0.970	1.08	0.971	1.04	0.595	3.56
	0-2.0	0.178	0.749	0.475	1.06	1.23	0.784	2.88
	0-4.0	0.170	1.68	0.439	1.16	1.35	1.04	2.59
	0-8.0	0.241	2.59	4.97	1.99	1.01	7.17	42.1
Dibenz(a,h)anthracene	0-0.5	0.179	0.992	0.196	1.10	1.11	0.373	4.14
	0-2.0	0.080	0.763	0.115	0.814	1.01	0.562	2.21
	0-4.0	0.076	1.14	0.121	1.21	1.17	0.738	1.70
	0-8.0	0.349	2.50	1.32	1.75	0.827	6.06	7.03

Table 5-17 (Page 2 of 2)
Exposure Point Concentrations for Individual Polynuclear Aromatic Hydrocarbons in Soil (milligrams per kilogram) - Current and Future Residents

Chemical	Depth Interval (feet bgs)	Area 1	2	3	4	5	6	7
Fluoranthene	0-0.5	2.71	3.90	1.22	4.70	4.04	1.94	23.830
	0-2.0	0.912	3.40	1.18	4.44	5.48	2.87	15.161
	0-4.0	0.867	7.75	0.854	5.79	6.19	4.22	15.980
	0-8.0	1.12	18.8	7.04	12.0	6.12	28.2	383
Fluorene	0-0.5	0.078	0.109	0.376	0.156	0.129	0.045	0.548
	0-2.0	0.022	0.062	0.040	0.099	0.116	0.045	0.174
	0-4.0	0.022	0.093	0.045	0.097	0.119	0.079	0.178
	0-8.0	0.026	0.048	0.359	0.623	0.088	0.377	18.2
Ideno(1,2,3-cd)pyrene	0-0.5	0.605	1.24	0.574	1.54	1.60	0.912	4.41
	0-2.0	0.242	0.986	0.423	1.82	2.03	1.88	4.51
	0-4.0	0.240	2.45	0.339	2.06	2.62	2.08	4.73
	0-8.0	0.343	3.55	4.13	2.56	1.84	8.93	50.1
Naphthalene	0-0.5	0.018	0.110	0.033	1.41	0.120	0.031	6.03
	0-2.0	0.092	0.061	0.028	0.044	0.104	0.062	2.20
	0-4.0	0.099	0.132	0.034	0.046	0.289	0.164	1.39
	0-8.0	0.038	0.120	0.309	1.17	0.342	1.99	70.5
Phenanthrene	0-0.5	0.455	0.906	0.280	1.06	1.27	0.681	8.13
	0-2.0	0.267	1.25	0.508	1.14	2.17	0.700	5.05
	0-4.0	0.224	2.31	0.337	1.47	2.08	1.43	4.61
	0-8.0	0.253	11.5	3.12	5.74	1.36	8.09	292
Pyrene	0-0.5	1.59	2.98	1.96	3.56	3.50	1.74	12.8
	0-2.0	0.581	2.56	1.43	3.62	4.32	2.15	10.3
	0-4.0	0.570	5.88	1.10	4.90	5.20	3.51	10.0
	0-8.0	0.650	16.4	8.06	10.6	4.70	22.7	241

bgs denotes below ground surface

because the Navy determined that fewer data were necessary to determine whether restrictions on excavation below 4 feet would be necessary. The decision to collect fewer metal samples was based on two assumptions: (1) that metals were unlikely to be associated with PAH contamination at OU-5, and (2) that metals (with the possible exception of background concentrations of arsenic) were unlikely to be risk drivers.

As described in Section 5.7, possible exposure to soils below four feet is associated with potential future construction activities at the site. Because EPA BaP-equivalent concentration data in the 4 to 8 feet depth interval do not support delineation of more than two distinct regions of relative homogeneity, and because site redevelopment is unlikely to be limited to areas as small as the decision areas, the two larger areas were used to generate EPCs for construction workers.

In order to maintain continuity in the residential risk assessments, EPCs for the 0 to 8 foot depth interval in each decision area will also be used to support an assessment of risk to future residents in the unlikely event that they may experience chronic exposure to deeper soils. However, confidence in these residential BaP-equivalent concentration soil values is lower than those in the upper three depth intervals since they do not correspond to regions of similar BaP-equivalent concentration soil concentrations. Therefore, any differences in calculated cancer risk or hazard among the seven decision areas for the 0 to 8 foot depth interval are not as meaningful as differences in the shallower intervals.

Table 5-18, "Exposure Point Concentrations for Benzo(a)pyrene-Equivalents in Soil – Construction Workers – EPA Methodology" and Table 5-19, "Exposure Point Concentrations for Benzo(a)pyrene-Equivalents in Soil – Construction Workers – CalEPA Methodology" present the EPCs for BaP-equivalent concentrations in the 0 to 8 foot depth interval for all of Parcel 181, the Northern Parcel and the Southern Parcel. Table 5-18 provides these results based on EPA methodology and Table 5-19 provides these results based on CalEPA methodology. Table 5-20, "Exposure Point Concentrations for Individual Polynuclear Aromatic Hydrocarbons in Soil (milligrams per kilogram) – Construction Workers" presents the EPCs for the individual PAHs for these same areas.

An initial evaluation of the spatial distribution of metals within Parcel 181 confirmed the first assumption described above. Only slight patterns in metals concentrations were discernable and these patterns did not coincide with PAH contamination. Figures 4-15 through 4-38 present plots of the soil concentrations of arsenic, cadmium, chromium, copper, lead, and mercury. As described in Section 4.1.2, the patterns observable in metal concentrations are associated with

differences in the spatial concentrations of metals that are generally smaller than the differences observed between OU-5 and Alameda background metal data sets.

To confirm the second assumption regarding risk related to metals, EPCs for metals were calculated. Table 5-21, "Exposure Point Concentrations for Inorganic Chemicals in Soil" summarizes the EPCs for OU-5 metals in the 0 to 0.5 foot bgs, 0 to 2 foot bgs, 0 to 4 foot bgs, and 0 to 8 foot bgs depth intervals. A decision was made to only calculate a single set of EPCs for each depth interval across the entire site instead of by decision area. This decision was made since there was no concern about diluting higher concentrations in one area with lower concentrations in another. In addition, there was concern that due to the relatively small number of samples, calculating metal EPCs for each of the seven decision areas would lead to higher uncertainty in the UCL calculations. If metals are determined to be significant risk drivers, additional samples may be required to confirm that the single set of EPCs adequately defines the incremental contribution of risk in each decision area.

As a conservative screening assessment, the maximum detected concentrations in soil gas were used in the residential and construction worker scenario risk calculations regardless of location on site. Likewise, for groundwater direct-push or monitoring wells, the maximum concentration detected in shallow groundwater (considered less than 12 feet) was used in the construction worker scenario risk calculations for inhalation exposure in a trench regardless of location on site.

5.8 Toxicity Assessment

The purpose of the toxicity assessment is to present the weight-of-evidence regarding the potential for a chemical to cause adverse effects in exposed individuals, and to quantitatively characterize, where possible, the relationship between exposure to a chemical and the increased likelihood and/or severity of adverse effects (dose-response assessment). Well conducted epidemiological studies that show a positive association between exposure to a chemical and a specific health effect are the most convincing evidence for predicting potential hazards for humans. However, human data that would be adequate to serve as the basis for the dose-response assessment are available for only a few chemicals. In most cases, toxicity assessment for a chemical has to rely on information derived from experiments conducted on non-human mammals, such as the rat, mouse, rabbit, guinea pig, hamster, dog, or monkey.

When the dose-response assessment is based on animal studies, it usually requires two types of extrapolation: high-to-low dose extrapolation and interspecies extrapolation. High-to-low dose extrapolation involves predicting the incidence rate of an adverse effect at low exposure levels

Table 5-18
Exposure Point Concentrations for Benzo(a)Pyrene-Equivalents in Soil - Construction Workers - EPA Methodology

Portion of Operable Unit 5	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
All of Parcel 181	0-8.0	10.4
Northern	0-8.0	19.5
Southern	0-8.0	2.64

bgs denotes below ground surface
mg/kg denotes milligrams per kilogram

Table 5-19
Exposure Point Concentrations for Benzo(a)Pyrene-Equivalents in Soil - Construction Workers - CalEPA Methodology

Portion of Operable Unit 5	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
All of Parcel 181	0-8.0	8.91
Northern	0-8.0	18.0
Southern	0-8.0	2.17

bgs denotes below ground surface
mg/kg denotes milligrams per kilogram

Table 5-20
Exposure Point Concentrations for Individual Polynuclear Aromatic Hydrocarbons in Soil (milligrams per kilogram) - Construction Workers

Chemical	Depth Interval (feet bgs)	Northern Parcel	Southern Parcel	All of Parcel 181
Acenaphthene	**0-8.0**	4.00	0.065	2.00
Acenaphthylene	**0-8.0**	3.68	0.465	1.45
Anthracene	**0-8.0**	14.7	0.213	3.48
Benzo(a)anthracene	**0-8.0**	9.61	0.717	4.29
Benzo(a)pyrene	**0-8.0**	13.6	1.54	6.47
Benzo(b)fluoranthene	**0-8.0**	8.96	1.09	4.10
Benzo(g,h,I)perylene	**0-8.0**	10.2	1.57	4.85
Benzo(k)fluoranthene	**0-8.0**	5.72	0.485	2.10
Chrysene	**0-8.0**	9.91	0.808	4.69
Dibenz(a,h)anthracene	**0-8.0**	4.84	1.00	3.28
Fluoranthene	**0-8.0**	64.7	4.29	24.3
Fluorene	**0-8.0**	6.56	0.076	0.719
Indeno(1,2,3-cd)pyrene	**0-8.0**	11.1	1.48	5.18
Naphthalene	**0-8.0**	11.4	0.342	3.24
Phenanthrene	**0-8.0**	61.8	1.19	14.1
Pyrene	**0-8.0**	42.3	2.99	17.8

bgs denotes below ground surface

Table 5-21 (Page 1 of 2)
Exposure Point Concentrations for Inorganic Chemicals in Soil

Chemical	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
Antimony	0-0.5	4.98
	0-2.0	4.59
	0-4.0	4.46
	0-8.0	4.79
Arsenic	0-0.5	4.11
	0-2.0	4.08
	0-4.0	4.57
	0-8.0	4.24
Barium	0-0.5	85.1
	0-2.0	86.2
	0-4.0	91.9
	0-8.0	75.6
Beryllium	0-0.5	0.262
	0-2.0	0.289
	0-4.0	0.341
	0-8.0	0.342
Cadmium	0-0.5	0.276
	0-2.0	0.257
	0-4.0	0.255
	0-8.0	0.297
Chromium (III)	0-0.5	37.5
	0-2.0	35.3
	0-4.0	42.7
	0-8.0	46.5
Chromium (VI)*	0-0.5	6.25
	0-2.0	5.88
	0-4.0	7.11
	0-8.0	7.75
Cobalt	0-0.5	9.41
	0-2.0	8.43
	0-4.0	9.83
	0-8.0	10.1
Copper	0-0.5	30.8
	0-2.0	25.9
	0-4.0	28.7
	0-8.0	26.6
Lead	0-0.5	39.7
	0-2.0	31.0
	0-4.0	29.4
	0-8.0	25.8
Mercury	0-0.5	0.225
	0-2.0	0.234
	0-4.0	0.286
	0-8.0	0.237

Table 5-21 (Page 2 of 2)
Exposure Point Concentrations for Inorganic Chemicals in Soil

Chemical	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)
Molybdenum	**0-0.5**	1.91
	0-2.0	2.92
	0-4.0	3.73
	0-8.0	3.09
Nickel	**0-0.5**	41.8
	0-2.0	38.5
	0-4.0	50.4
	0-8.0	54.8
Selenium	**0-0.5**	0.497
	0-2.0	0.540
	0-4.0	0.565
	0-8.0	1.01
Silver	**0-0.5**	0.451
	0-2.0	0.444
	0-4.0	0.467
	0-8.0	0.501
Thallium	**0-0.5**	0.939
	0-2.0	1.06
	0-4.0	1.01
	0-8.0	1.90
Vanadium	**0-0.5**	32.6
	0-2.0	32.4
	0-4.0	37.9
	0-8.0	40.1
Zinc	**0-0.5**	88.6
	0-2.0	71.2
	0-4.0	79.3
	0-8.0	69.8

bgs denotes below ground surface

mg/kg denotes milligrams per kilogram

** Assumes total chromium is present as a 1:6 ratio of CrVI:CrIII.*

based on the results obtained at high exposure levels. Interspecies extrapolation involves predicting the likelihood of an adverse effect in humans based on results obtained from animal studies. In the absence of evidence to the contrary, it is assumed that adverse effects observed in animals will also occur in humans.

Chemicals are usually evaluated for their potential health effects in two categories, carcinogenic and noncarcinogenic. Different methods are used to estimate the potential for carcinogenic and noncarcinogenic health effects to occur. All chemicals produce noncarcinogenic effects at sufficiently high doses but only some chemicals are associated with carcinogenic effects. Most regulatory agencies consider carcinogens to pose a risk for cancer at all exposure levels (i.e., a "no-threshold" assumption); that is, any increase in dose is associated with an increase in the probability of developing cancer. In contrast, noncarcinogens generally are thought to produce adverse health effects only when some minimum exposure level is reached (i.e., a threshold dose).

Sections 5.8.1 and 5.8.2 describe the methods used for the chronic toxicity assessment of carcinogens and noncarcinogens, respectively. Section 5.8.3 identifies the hierarchy of sources used to select toxicity values for this assessment.

5.8.1 Carcinogenic Effects

Current health risk assessment practice for carcinogens is based on the assumption that there is no threshold dose below which carcinogenic effects do not occur. This current "no-threshold" assumption for carcinogenic effects is based on an assumption that the carcinogenic processes are the same at high and low doses. This approach has generally been adopted by regulatory agencies as a conservative practice to protect public health. The "no-threshold" assumption is used in this risk assessment for evaluating carcinogenic effects. Although the magnitude of the risk declines with decreasing exposure, the risk is believed to be zero only at zero exposure.

There are two components to the assessment of the carcinogenic effects of a chemical: a qualitative determination of the likelihood of it being a human carcinogen (weight-of-evidence), and a quantitative assessment of the relationship between exposure dose and response (i.e., CSF). Using the weight-of-evidence approach, the EPA's Carcinogen Assessment Group categorizes

chemicals into Groups A, B, C, D, and E carcinogens (EPA, 1989). The Carcinogen Assessment Group's classification of carcinogens is briefly described below:

- **Group A – Human Carcinogen**
  - This category indicates that there is sufficient evidence available from human epidemiological studies to support a causal association between exposure to the chemical and the development of human cancer.
- **Group B – Probable Human Carcinogen**
  - This category indicates that sufficient evidence exists from animal studies to support a causal relationship between exposure to the chemical and the development of cancer in animals. This category is divided into subgroups B1 and B2. Group B1 chemicals also have limited evidence for carcinogenicity from human epidemiological studies. Group B2 chemicals have inadequate or no evidence from epidemiological studies.
- **Group C – Possible Human Carcinogen**
  - This category is for chemicals that exhibit limited evidence of carcinogenicity in animals.
- **Group D – Not Classifiable as to Human Carcinogenicity**
  - This category is used for chemicals with inadequate human and animal evidence of carcinogenicity.
- **Group E – Evidence of Noncarcinogenicity for Humans**
  - This category is used for chemicals that show no evidence of carcinogenicity in at least two adequate animal tests in different species or in both adequate epidemiological and animal studies.

Cancer slope factors are used to quantify the response potency of a potential carcinogen. Cancer slope factors are typically calculated for carcinogens in Groups A, B1, and B2. The EPA decides to derive CSFs for Group C chemicals on a case-by-case basis.

Cancer slope factors may be based on either human epidemiological or animal data and are calculated by applying a mathematical model to extrapolate from responses observed at relatively high exposure doses in the studies to responses expected at lower doses of human exposure to environmental contaminants. A number of mathematical models and procedures have been developed for the extrapolation. In the absence of adequate data to the contrary, the linearized multistage model is employed (EPA, 1989).

In general, the CSF is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical, e.g., $(mg/kg/day)^{-1}$, over a lifetime. The CSF is used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer as a result of

exposure to a particular level of a potential carcinogen. The true value of the risk is unknown, and may be as low as zero.

5.8.2 Noncarcinogenic Effects

The dose-response assessment for noncarcinogenic effects requires the derivation of an exposure level below which no adverse health effects in humans are expected to occur. These levels are referred to as reference doses (RfD) for oral exposure and reference concentrations (RfC) for inhalation exposure (EPA, 1989). For the characterization of the potential noncarcinogenic health effects, inhalation RfCs, which the EPA generally reports as concentrations in air, are converted to corresponding inhaled doses (inhalation RfDs) using EPA-approved interim methodology (1989).

Reference doses and RfCs are calculated by dividing a quantitative toxicity index, derived from human or animal studies, by an appropriate safety or uncertainty factor. The quantitative toxicity indices that may be used for the derivation of RfDs or RfCs include the No-Observed-Effect-Level (NOEL), the No-Observed-Adverse-Effect-Level, the Lowest-Observed-Effect-Level, and the Lowest-Observed-Adverse-Effect-Level (EPA, 1989).

As stated in EPA guidance (1989), subchronic RfDs have been developed for some chemicals and may be used in situations where the expected exposure duration is considerably less than lifetime. Such is the case for the construction worker scenario, which assumes exposure duration of one year. However, instead of using the relatively limited subchronic toxicity data available, the more conservative chronic RfDs were used for the construction worker in this assessment.

5.8.3 Sources of Toxicity Values

As discussed earlier in this section, this risk assessment has been dual tracked using both EPA and CalEPA methodology. Consistent with EPA guidance (1989), the hierarchy of sources for the toxicity criteria used for the EPA methodology is as follows:

- *Integrated Risk Information Service (IRIS)* (EPA, 2001) (http://www.epa.gov/iriswebp/iris/index.html)
- *Health Effects Assessment Summary Tables (HEAST)* (1997b)
- National Center for Environmental Assessment (EPA, 2000a).

In addition, for some chemicals with no EPA toxicity values, a CalEPA toxicity value has been used.

For the CalEPA methodology, the hierarchy of sources for the toxicity criteria is similar, however the primary source is as follows:

- CalEPA CSFs, RfDs, and RfCs (2002) (http://www.oehha.ca.gov/risk/ChemicalDB/indes.asp)

5.8.3.1 Cancer Slope Factors

Table 5-22, "Summary of Carcinogenic Toxicity Data – EPA Methodology" and Table 5-23, "Summary of Carcinogenic Toxicity Data – CalEPA Methodology" present the oral and inhalation CSFs used in this risk assessment. Where available, the table also presents the classification of carcinogens according to the weight-of-evidence. Specific dermal route CSFs have not yet been developed for any chemicals. Consistent with EPA and CalEPA guidance, potential health effects associated with dermal exposure are calculated using the oral toxicity factors.

According to the EPA, the carcinogenic PAHs include benz(a)anthracene, BaP, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. These chemicals are identified as Class B2 or probable human carcinogens based on several studies.

To date, there are limited CSFs available for all carcinogenic PAHs. Cancer slope factors have, however, been developed for BaP. The EPA oral CSF for BaP is 7.3 $(mg/kg/day)^{-1}$. This value is based on the geometric mean of four CSFs derived using different modeling approaches on a combined data set of tumor data from more than one sex and species of mice. The target effects of these dietary studies were increased incidence of forestomach, larynx, and esophagus papillomas and carcinomas. The EPA considers the data used to derive this CSF acceptable although less than optimal (EPA, 2001). For inhalation exposures, the National Center for Environmental Assessment has recommended a CSF of 3.1 $(mg/kg\text{-}day)^{-1}$ for BaP (EPA, 2000a).

The CalEPA oral CSF for BaP is 12 $(mg/kg/day)^{-1}$. This value is based on the gastric tumor incidence in male and female mice, with the CSF calculated using a linearized multistage procedure (CalEPA, 1999). For inhalation exposures, CalEPA has a CSF of 3.9 $(mg/kg\text{-}day)^{-1}$ for BaP.

Since the available data is considered insufficient to calculate CSFs for the other carcinogenic PAHs, CSFs for these compounds are typically derived relative to BaP based on the EPA or CalEPA toxicity equivalence scheme. Under this method, the agencies have used the available toxicity data for the other PAHs to derive relative potencies for each carcinogenic PAH. These

Table 5-22 (Page 1 of 3)
Summary of Carcinogenic Toxicity Data - EPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	EPA Weight of Evidence
Volatile Organic Compounds					
Acenaphthene	NC		NC		
Acetone	NC		NC		D
Anthracene	NC		NC		D
Benzene	$2.70x10^{-2}$	IRIS	$5.50x10^{-2}$	IRIS	A
Bromodichloromethane	$6.20x10^{-2}$	a	$6.20x10^{-2}$	IRIS	B2
2-Butanone	NC		NC		D
n-Butylbenzene	NC		NC		
sec-Butylbenzene	NC		NC		
Carbon Disulfide	NC		NC		
Chlorobenzene	NC		NC		D
Chloroethane	$2.90x10^{-3}$	a	$2.90x10^{-3}$	NCEA	
Chloroform	$8.10x10^{-2}$	IRIS	$6.10x10^{-3}$	IRIS	B2
4-Chlorotoluene	NC		NC		
Dibromochloromethane	$8.40x10^{-2}$	a	$8.40x10^{-2}$	IRIS	C
1,2-Dichlorobenzene	NC		NC		D
Dichlorodifluoromethane	NC		NC		
1,1-Dichloroethane	NC		NC		D
1,2-Dichloroethane	$9.10x10^{-2}$	IRIS	$9.10x10^{-2}$	IRIS	B2
1,1-Dichloroethene	$1.75x10^{-1}$	IRIS	$6.00x10^{-1}$	IRIS	C
cis-1,2-Dichloroethene	NC		NC		D
trans-1,2-Dichloroethene	NC		NC		
Ethylbenzene	NC		NC		D
Fluorene	NC		NC		D
2-Hexanone	NC		NC		
Isopropyl Benzene	NC		NC		D
4-Isopropyltoluene	NA		NA		
Methylene Chloride	$1.60x10^{-3}$	IRIS	$7.50x10^{-3}$	IRIS	B2
4-Methyl-2-Pentanone	NC		NC		
Methyl tert-Butyl Ether	$1.80x10^{-3}$	Cal/EPA	$1.80x10^{-3}$	Cal/EPA	
Naphthalene	NA		NA		C
Phenanthrene	NC		NC		D
Pyrene	NC		NC		D
n-Propylbenzene	NC		NC		
Styrene	NC		NC		
1,1,1,2-Tetrachloroethane	$2.59x10^{-2}$	IRIS	$2.60x10^{-2}$	IRIS	C
Tetrachloroethene	$2.00x10^{-3}$	NCEA	$5.20x10^{-2}$	NCEA	C-B2
Toluene	NC		NC		D
1,1,1-Trichloroethane	NC		NC		D
Trichloroethene	$6.00x10^{-3}$	NCEA	$1.10x10^{-2}$	NCEA	C-B2
1,2,4-Trimethylbenzene	NC		NC		

Table 5-22 (Page 2 of 3)
Summary of Carcinogenic Toxicity Data - EPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	Evidence
Volatile Organic Compounds (continued)					
1,3,5-Trimethylbenzene	NC		NC		
Vinyl Acetate	NC		NC		
Vinyl Chloride	$3.10x10^{-2}$	IRIS	$1.50x10^{0}$	IRIS	A
Xylenes (Total)	NC		NC		D
Semivolatile Organic Compounds					
Acenaphthylene	NC		NC		D
Benzo(a)anthracene	$3.10x10^{-1}$	NCEA	$7.30x10^{-1}$	NCEA	B2
Benzo(a)pyrene	$3.10x10^{0}$	NCEA	$7.30x10^{0}$	IRIS	B2
Benzo(b)fluoranthene	$3.10x10^{-1}$	NCEA	$7.30x10^{-1}$	NCEA	B2
Benzo(g,h,i)perylene	NC		NC		D
Benzo(k)fluoranthene	$3.10x10^{-2}$	NCEA	$7.30x10^{-2}$	NCEA	B2
Chrysene	$3.10x10^{-3}$	NCEA	$7.30x10^{-3}$	NCEA	B2
Dibenz(a,h)anthracene	$3.10x10^{0}$	NCEA	$7.30x10^{0}$	NCEA	B2
Fluoranthene	NC		NC		D
Indeno(1,2,3-cd)pyrene	$3.10x10^{-1}$	NCEA	$7.30x10^{-1}$	NCEA	B2
Inorganic Compounds					
Aluminum	NC		NC		
Antimony	NC		NC		
Arsenic	$1.50x10^{1}$	IRIS	$1.50x10^{0}$	IRIS	A
Barium	NC		NC		D
Beryllium	$8.40x10^{0}$	IRIS	NA		B1 (inh)
Cadmium	$6.30x10^{0}$	IRIS	NA		B1 (inh)
Chromium (III)	NC		NC		D
Chromium (VI)	$4.20x10^{1}$	IRIS	NA		A (inh); D (oral)
Cobalt	NC		NC		
Copper	NC		NC		D
Magnesium	NC		NC		
Manganese	NC		NC		
Mercury	NC		NC		D
Molybdenum	NC		NC		
Nickel	$1.68x10^{0}$	IRIS[b]	NA		A (inh)
Selenium	NC		NC		D

Table 5-22 (Page 3 of 3)
Summary of Carcinogenic Toxicity Data - EPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	EPA Weight of Evidence
Inorganic Compounds (continued)					
Silver	NC		NC		D
Thallium	NC		NC		D
Vanadium	NC		NC		
Zinc	NC		NC		D

NA denotes Not available

NC denotes Not known to be a carcinogen

mg/kg-d denotes milligrams per kilogram per day

inh denotes inhalation

[a] *Based on route-to-route extrapolation, assuming equal absorption between the two routes.*

[b] *Toxicity value for nickel subsulfide used as a surrogate for nickel.*

California Environmental Protection Agency (Cal/EPA), 2001, Toxicity Criteria Database, *Online database maintained by the Office of Environmental Health Hazard Assessment, http://www.oehha.org/risk.html.*

National Center for Environmental Assessment (NCEA), November 1, 2000, Cited in EPA Region 9 Preliminary Remediation Goals (PRGs) 2000, *San Francisco, California.*

U.S. Environmental Protection Agency (EPA), 2001, Integrated risk information system (IRIS), *Online database maintained by the EPA, Cincinnati, Ohio.*

Table 5-23 (Page 1 of 3)
Summary of Carcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor (CSF) $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	EPA Weight of Evidence
Volatile Organic Compounds					
Acenaphthene	NA		NA		
Acetone	NC		NC		D
Anthracene	NC		NC		D
Benzene	$1.0x10^{-1}$	Cal/EPA	$1.0x10^{-1}$	Cal/EPA	A
Bromodichloromethane	$1.3x10^{-1}$	Cal/EPA	$1.3x10^{-1}$	Cal/EPA	B2
2-Butanone (methyl ethyl ketone)	NC		NC		D
n-Butylbenzene	NA		NA		
sec-Butylbenzene	NA		NA		
Carbon Disulfide	NA		NA		
Chlorobenzene	NC		NC		D
Chloroethane	$2.9x10^{-3}$	a	$2.9x10^{-3}$	NCEA	
Chloroform	$1.9x10^{-2}$	Cal/EPA	$3.1x10^{-2}$	Cal/EPA	B2
4-Chlorotoluene	NA		NA		
Dibromochloromethane	$8.4x10^{-2}$	a	$8.4x10^{-2}$	IRIS	C
1,2-Dichlorobenzene	NC		NC		D
Dichlorodifluoromethane (freon 12)	NA		NA		
1,1-Dichloroethane	$5.7x10^{-3}$	Cal/EPA	$5.7x10^{-3}$	Cal/EPA	C
1,2-Dichloroethane	$7.2x10^{-2}$	Cal/EPA	$4.7x10^{-2}$	Cal/EPA	B2
1,1-Dichloroethene	NC	Cal/EPA	NC	Cal/EPA	C
cis-1,2-Dichloroethene	NC		NC		D
trans-1,2-Dichloroethene	NA		NA		
Ethylbenzene	NC		NC		D
Fluorene	NC		NC		D
2-Hexanone (methyl butyl ketone)	NA		NA		
Isopropyl Benzene	NC		NC		D
4-Isopropyltoluene	NA		NA		
Methylene Chloride	$3.5x10^{-3}$	Cal/EPA	$1.4x10^{-2}$	Cal/EPA	B2
4-Methyl-2-Pentanone (methyl isobutyl ketone)	NA		NA		
Methyl tert-Butyl Ether	$1.8x10^{-3}$	Cal/EPA	$1.8x10^{-3}$	Cal/EPA	
Naphthalene	NA		NA		C
Phenanthrene	NC		NC		D
Pyrene	NC		NC		D
n-Propylbenzene	NA		NA		
Styrene	NA		NA		
1,1,1,2-Tetrachloroethane	$2.6x10^{-2}$	IRIS	$2.6x10^{-2}$	IRIS	C
Tetrachloroethene	$2.1x10^{-2}$	Cal/EPA	$5.1x10^{-2}$	Cal/EPA	C-B2
Toluene	NC		NC		D
1,1,1-Trichloroethane	NC		NC		D
Trichloroethene	$1.0x10^{-2}$	Cal/EPA	$1.5x10^{-2}$	Cal/EPA	C-B2

Table 5-23 (Page 2 of 3)
Summary of Carcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor (CSF) $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	EPA Weight of Evidence
Volatile Organic Compounds (continued)					
1,2,4-Trimethylbenzene	NA		NA		
1,3,5-Trimethylbenzene	NA		NA		
Vinyl Acetate	NA		NA		
Vinyl Chloride	$2.7x10^{-1}$	Cal/EPA	$2.7x10^{-1}$	Cal/EPA	A
Xylenes (Total)	NC		NC		D
Semivolatile Organic Compounds					
Acenaphthylene	NC		NC		D
Benzo(a)anthracene	$3.9x10^{-1}$	Cal/EPA	$1.2x10^{0}$	Cal/EPA	B2
Benzo(a)pyrene	$3.9x10^{0}$	Cal/EPA	$1.2x10^{1}$	Cal/EPA	B2
Benzo(b)fluoranthene	$3.9x10^{-1}$	Cal/EPA	$1.2x10^{0}$	Cal/EPA	B2
Benzo(g,h,i)perylene	NC		NC		D
Benzo(k)fluoranthene	$3.9x10^{-1}$	Cal/EPA	$1.2x10^{0}$	Cal/EPA	B2
Chrysene	$3.9x10^{-2}$	Cal/EPA	$1.2x10^{-1}$	Cal/EPA	B2
Dibenz(a,h)anthracene	$4.1x10^{0}$	Cal/EPA	$4.1x10^{0}$	Cal/EPA	B2
Fluoranthene	NC		NC		D
Indeno(1,2,3-cd)pyrene	$3.9x10^{-1}$	Cal/EPA	$1.2x10^{0}$	Cal/EPA	B2
Inorganic Compounds					
Aluminum	NA		NA		
Antimony	NA		NA		
Arsenic	$1.2x10^{1}$	Cal/EPA	$1.5x10^{0}$	Cal/EPA	A
Barium	NC		NC		D
Beryllium	$8.4x10^{0}$	Cal/EPA	NC		B1(inh)
Cadmium (+2)	$1.5x10^{1}$	Cal/EPA	$3.8x10^{-1}$	Cal/EPA	B1
Chromium (III)	NC		NC		D
Chromium (VI)	$5.1x10^{2}$	Cal/EPA	NC		A (inh); D (oral)
Cobalt	NA		NA		
Copper	NC		NC		D
Magnesium	NA		NA		
Manganese	NC		NC		D
Mercury	NC		NC		D
Molybdenum	NA		NA		
Nickel	$9.1x10^{-1}$	Cal/EPA	NC		A
Selenium	NC		NC		D
Silver	NC		NC		D

Table 5-23 (Page 3 of 3)
Summary of Carcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values				
	Cancer Slope Factor (CSF) $(mg/kg\text{-}d)^{-1}$				
	Inhalation	Source	Oral	Source	EPA Weight of Evidence
Inorganic Compounds (continued)					
Thallium	NC		NC		D
Vanadium	NA		NA		
Zinc	NC		NC		D

NA denotes Not available

NC denotes Not listed as a carcinogen

a - Based on route-to-route extrapolation, assuming equal absorption between the two routes.

Sources:

California Environmental Protection Agency (Cal/EPA). 2001. Toxicity Criteria Database. Online database maintained by the Office of Environmental Health Hazard Assessment. http://www.oehha.org/risk.html

National Center for Environmental Assessment (NCEA). 2000. Cited in EPA Region 9 Preliminary Remediation Goals (PRGs) 2000. San Francisco, CA. November 1.

United States Environmental Protection Agency (EPA). 2001. Integrated risk information system (IRIS). Online database maintained by the EPA. Cincinnati, OH.

potencies and corresponding CSFs are presented in Table 5-24, "Potency Factors and Cancer Slope Factors – EPA Methodology" and Table 5-25, "Potency Factors and Cancer Slope Factors – CalEPA Methodology."

5.8.3.2 Noncancer Reference Doses

Table 5-26, "Summary of Noncarcinogenic Toxicity Data – EPA Methodology" and Table 5-27, "Summary of Noncarcinogenic Toxicity Data – CalEPA Methodology" present the oral and inhalation RfDs used in this risk assessment. As with CSFs, specific dermal route RfDs have not yet been developed for any chemicals. Consistent with EPA and CalEPA guidance, potential health effects associated with dermal exposure are calculated using the oral toxicity factors.

For some chemicals detected at the site, RfDs were not available in the guidance. In these cases, toxicity values from a structurally similar surrogate chemical were used. As noted in Table 5-26 and Table 5-27, toxicity values for naphthalene were used as surrogates for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene. Naphthalene was chosen as a surrogate because it has the lowest, and therefore most conservative RfDs of all the PAHs detected.

The traditional RfD approach to the evaluation of chemicals is not applied to inorganic lead because most human health effects data are based on blood lead concentrations, rather than external dose. Blood lead concentration is an integrated measure of internal dose; reflecting total exposure from site-related and background sources. A clear NOEL has not been established for such lead-related endpoints as birth weight, gestation period, heme synthesis, and neurobehavioral development in children and fetuses, and blood pressure in middle-aged men. Dose-response curves for these endpoints appear to extend down to 10 micrograms per deciliter or less. For this assessment, measured concentrations of lead in soil will be screened by comparison to the EPA Region 9 Preliminary Remediation Goals (PRG) for lead of 400 mg/kg for residential soil and 750 mg/kg for industrial soil (EPA, 2000b).

5.9 Risk Characterization

Risk characterization is the final step of the risk assessment. It is defined as the combination of the exposure assessment and toxicity assessment to produce an estimate of risk and noncancer hazard, along with a characterization of uncertainties in the estimated risk. This section presents the results of the risk assessment for the site. In Section 5.9.1, the methods for estimating cancer risks and noncancer HIs are discussed. Sections 5.9.2, 5.9.3, and 5.9.4 present the estimated cancer risks and chronic noncancer HIs for current residents, future residents and construction workers, respectively. Section 5.9.5 evaluates risks associated with background or ambient concentrations of inorganic compounds. A summary of the cumulative risks for all populations

evaluated is presented in Section 5.9.6. The screening evaluation for chemicals detected in soils on off site properties is discussed in Section 5.9.7. Uncertainties that may result from various assumptions used in the risk assessment are discussed in Section 5.9.8.

5.9.1 Methods Used to Quantify Risk

Estimating cancer risks and noncancer HIs requires information regarding the level of intake of the chemical and the relationship between intake of the chemical and its toxicity as a function of human exposure to the chemical. The methodology used to derive the cancer risks and noncancer HIs for the selected chemicals is based on guidance provided by EPA (1989).

One can estimate the potential risk associated with a chemical in all media using equations that describe the relationships among the estimated intake of site-related chemicals, toxicity of the specific chemicals, and overall risk for carcinogenic and noncarcinogenic health effects. For carcinogenic effects, the relationship is given by the following equation (EPA, 1989):

$$Risk = I \times CSF$$

Where:

Risk	=	Cancer Risk; the probability of an individual developing cancer as a result of exposure to a particular cumulative dose of a potential carcinogen (unitless)
I	=	Intake of a chemical (mg chemical/kg body weight-day)
CSF	=	Cancer Slope Factor (mg chemical/kg body weight-day)$^{-1}$

The relationship for noncarcinogenic effects is given by the following equation (EPA, 1989):

$$HI = \frac{I}{RfD}$$

Where:

HI	=	Hazard Index; an expression of the potential for noncarcinogenic effects, which relates the allowable amount of a chemical (RfD) to the estimated site-specific intake (unitless)
I	=	Intake of chemical (mg chemical/kg body weight-day)
RfD	=	Reference Dose; the toxicity value indicating the threshold amount of chemical contacted below which no adverse health effects are expected (mg chemical/kg body weight-day).

Table 5-24
Potency Factors and Cancer Slope Factors – EPA Methodology

Compound	Toxicity Equivalency Factor Applied	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$
Benzo(a)anthracene	0.1	7.3×10^{-1}	3.1×10^{-1}
Benzo(a)pyrene	1.0	7.3×10^{0}	3.1×10^{0}
Benzo(b)fluoranthene	0.1	7.3×10^{-1}	3.1×10^{-1}
Benzo(k)fluoranthene	0.01	7.3×10^{-2}	3.1×10^{-2}
Chrysene	0.001	7.3×10^{-3}	3.1×10^{-3}
Dibenz(a,h)anthracene	1.0	7.3×10^{0}	3.1×10^{0}
Indeno(1,2,3-cd)pyrene	0.1	7.3×10^{-1}	3.1×10^{-1}

mg/kg/day denotes milligram(s) per kilogram per day

Table 5-25
Potency Factors and Cancer Slope Factors – CalEPA Methodology

Compound	Toxicity Equivalency Factor Applied	Oral Cancer Slope Factor $(mg/kg/day)^{-1}$	Inhalation Cancer Slope Factor $(mg/kg/day)^{-1}$
Benzo(a)anthracene	0.1	1.2×10^{0}	3.9×10^{-1}
Benzo(a)pyrene	1.0	1.2×10^{1}	3.9×10^{0}
Benzo(b)fluoranthene	0.1	1.2×10^{0}	3.9×10^{-1}
Benzo(k)fluoranthene	0.1	1.2×10^{0}	3.9×10^{-1}
Chrysene	0.01	1.2×10^{-1}	3.9×10^{-2}
Indeno(1,2,3-cd)pyrene	0.1	1.2×10^{0}	3.9×10^{-1}

mg/kg/day denotes milligram(s) per kilogram per day

For dibenz(a,h)anthracene, CalEPA has a separate oral and inhalation CSF of 4.1 $(mg/kg\text{-}day)^{-1}$

Table 5-26 (Page 1 of 3)
Summary of Noncarcinogenic Toxicity Data - EPA Methodology

	Toxicity Values			
	Noncancer Reference Dose (mg/kg-d)			
Chemical	Inhalation	Source	Oral	Source
Volatile Organic Compounds				
Acenaphthene	$6.00x10^{-2}$	a	$6.00x10^{-2}$	IRIS
Acetone	$1.00x10^{-1}$	a	$1.00x10^{-1}$	IRIS
Anthracene	$3.00x10^{-1}$	a	$3.00x10^{-1}$	IRIS
Benzene	$1.70x10^{-3}$	NCEA	$3.00x10^{-3}$	NCEA
Bromodichloromethane	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
2-Butanone	$2.90x10^{-1}$	IRIS	$6.00x10^{-1}$	IRIS
n-Butylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
sec-Butylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
Carbon Disulfide	$2.00x10^{-1}$	IRIS	$1.00x10^{-1}$	IRIS
Chlorobenzene	$1.70x10^{-2}$	NCEA	$2.00x10^{-2}$	IRIS
Chloroethane	$2.90x10^{0}$	IRIS	$4.00x10^{-1}$	NCEA
Chloroform	$8.60x10^{-5}$	NCEA	$1.00x10^{-2}$	IRIS
4-Chlorotoluene	$2.00x10^{-2}$	a,c	$2.00x10^{-2}$	IRIS[c]
Dibromochloromethane	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
1,2-Dichlorobenzene	$5.71x10^{-2}$	HEAST	$9.00x10^{-2}$	IRIS
Dichlorodifluoromethane	$5.70x10^{-2}$	HEAST	$2.00x10^{-1}$	IRIS
1,1-Dichloroethane	$1.40x10^{-1}$	HEAST	$1.00x10^{-1}$	HEAST
1,2-Dichloroethane	$1.40x10^{-3}$	NCEA	$3.00x10^{-2}$	NCEA
1,1-Dichloroethene	$9.00x10^{-3}$	a	$9.00x10^{-3}$	IRIS
cis-1,2-Dichloroethene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	HEAST
trans-1,2-Dichloroethene	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
Ethylbenzene	$2.90x10^{-1}$	IRIS	$1.00x10^{-1}$	IRIS
Fluorene	$4.00x10^{-2}$	a	$4.00x10^{-2}$	IRIS
2-Hexanone	NA		NA	
Isopropyl Benzene	$1.14x10^{-1}$	IRIS	$1.00x10^{-1}$	IRIS
4-Isopropyltoluene	NA		NA	
Methylene Chloride	$8.60x10^{-1}$	HEAST	$6.00x10^{-2}$	IRIS
4-Methyl-2-Pentanone	$2.30x10^{-2}$	HEAST	$8.00x10^{-2}$	HEAST
Methyl tert-Butyl Ether	$8.60x10^{-1}$	IRIS	$3.00x10^{-2}$	EPA 1999
Naphthalene	$8.57x10^{-4}$	IRIS	$2.00x10^{-2}$	IRIS
Phenanthrene	$8.57x10^{-4}$	IRIS[b]	$2.00x10^{-2}$	IRIS[b]
Pyrene	$3.00x10^{-2}$	a	$3.00x10^{-2}$	IRIS
n-Propylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
Styrene	$2.90x10^{-1}$	IRIS	$2.00x10^{-1}$	IRIS
1,1,1,2-Tetrachloroethane	$3.00x10^{-2}$	a	$3.00x10^{-2}$	IRIS
Tetrachloroethene	$1.10x10^{-1}$	NCEA	$1.00x10^{-2}$	IRIS
Toluene	$1.10x10^{-1}$	IRIS	$2.00x10^{-1}$	IRIS
1,1,1-Trichloroethane	$2.90x10^{-1}$	NCEA	$2.00x10^{-2}$	NCEA
Trichloroethene	$7.35x10^{-3}$	a	$7.35x10^{-3}$	DTSC
1,2,4-Trimethylbenzene	$1.70x10^{-3}$	NCEA	$5.00x10^{-2}$	NCEA

Table 5-26 (Page 2 of 3)
Summary of Noncarcinogenic Toxicity Data - EPA Methodology

Chemical	Toxicity Values			
	Noncancer Reference Dose (mg/kg-d)			
	Inhalation	Source	Oral	Source
Volatile Organic Compounds (continued)				
1,3,5-Trimethylbenzene	$1.70x10^{-3}$	NCEA	$5.00x10^{-2}$	NCEA
Vinyl Acetate	$5.71x10^{-2}$	IRIS	$1.00x10^{0}$	HEAST
Vinyl Chloride	$2.90x10^{-2}$	IRIS	$3.00x10^{-3}$	IRIS
Xylenes (Total)	$2.00x10^{0}$	a	$2.00x10^{0}$	IRIS
Semivolatile Organic Compounds				
Acenaphthylene	$8.57x10^{-4}$	IRIS[b]	$2.00x10^{-2}$	IRIS[b]
Benzo(a)anthracene	NA		NA	
Benzo(a)pyrene	NA		NA	
Benzo(b)fluoranthene	NA		NA	
Benzo(g,h,i)perylene	$8.57x10^{-4}$	IRIS[b]	$2.00x10^{-2}$	IRIS[b]
Benzo(k)fluoranthene	NA		NA	
Chrysene	NA		NA	
Dibenz(a,h)anthracene	NA		NA	
Fluoranthene	$4.00x10^{-2}$	a	$4.00x10^{-2}$	IRIS
Indeno(1,2,3-cd)pyrene	NA		NA	
Inorganic Compounds				
Aluminum	$1.40x10^{-3}$	NCEA	$1.00x10^{0}$	NCEA
Antimony	NA		$4.00x10^{-4}$	IRIS
Arsenic	$8.57x10^{-6}$	Cal/EPA	$3.00x10^{-4}$	IRIS
Barium	$1.40x10^{-4}$	HEAST	$7.00x10^{-2}$	IRIS
Beryllium	$5.70x10^{-6}$	IRIS	$2.00x10^{-3}$	IRIS
Cadmium	$5.71x10^{-6}$	Cal/EPA	$5.00x10^{-4}$	IRIS
Chromium (III)	NA		$1.50x10^{0}$	IRIS
Chromium (VI)	$2.90x10^{-5}$	IRIS	$3.00x10^{-3}$	IRIS
Cobalt	NA		$6.00x10^{-2}$	NCEA
Copper	NA		$3.70x10^{-2}$	HEAST
Magnesium	NA		NA	
Manganese	$1.40x10^{-5}$	IRIS	$1.40x10^{-1}$	IRIS
Mercury	$8.57x10^{-5}$	IRIS	$8.57x10^{-5}$	a
Molybdenum	NA		$5.00x10^{-3}$	HEAST
Nickel	$1.43x10^{-5}$	Cal/EPA	$2.00x10^{-2}$	IRIS[d]
Selenium	NA		$5.00x10^{-3}$	IRIS
Silver	NA		$5.00x10^{-3}$	IRIS

Table 5-26 (Page 3 of 3)
Summary of Noncarcinogenic Toxicity Data - EPA Methodology

Chemical	Toxicity Values			
	Noncancer Reference Dose (mg/kg-d)			
	Inhalation	Source	Oral	Source
Inorganic Compounds (continued)				
Thallium	NA		$6.60x10^{-5}$	EPA 2000
Vanadium	NA		$7.00x10^{-3}$	HEAST
Zinc	NA		$3.00x10^{-1}$	IRIS

NA denotes Not available

mg/kg-d denotes milligrams per kilogram per day

[a] *Based on route-to-route extrapolation, assuming equal absorption between the two routes.*

[b] *Toxicity values for naphthalene were used as surrogates for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene, because it has the lowest (most conservative) RfDs of the PAHs.*

[c] *Toxicity values for o-chlorotoluene were used as surrogates for 4-chlorotoluene.*

[d] *Toxicity value for nickel soluble salts used as a surrogate for nickel.*

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U.S. Environmental Protection Agency (EPA), November 1, 2000, Region 9 Preliminary Remediation Goals, *San Francisco, California.*

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Table 5-27 (Page 1 of 3)
Summary of Noncarcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values: Noncancer Reference Dose (RfD) mg/kg-d			
	Inhalation	Source	Oral	Source
Volatile Organic Compounds				
Acenaphthene	$6.00x10^{-2}$	a	$6.00x10^{-2}$	IRIS
Acetone	$1.00x10^{-1}$	a	$1.00x10^{-1}$	IRIS
Anthracene	$3.00x10^{-1}$	a	$3.00x10^{-1}$	IRIS
Benzene	$1.71x10^{-2}$	Cal/EPA	$3.00x10^{-3}$	NCEA
Bromodichloromethane	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
2-Butanone	$2.90x10^{-1}$	IRIS	$6.00x10^{-1}$	IRIS
n-Butylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
sec-Butylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
Carbon Disulfide	$2.29x10^{-1}$	Cal/EPA	$1.00x10^{-1}$	IRIS
Chlorobenzene	$2.86x10^{-1}$	Cal/EPA	$2.00x10^{-2}$	IRIS
Chloroethane	$8.57x10^{0}$	Cal/EPA	$4.00x10^{-1}$	NCEA
Chloroform	$8.57x10^{-2}$	Cal/EPA	$1.00x10^{-2}$	IRIS
4-Chlorotoluene	$2.00x10^{-2}$	b	$2.00x10^{-2}$	b
Dibromochloromethane	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
1,2-Dichlorobenzene	$5.71x10^{-2}$	HEAST	$9.00x10^{-2}$	IRIS
Dichlorodifluoromethane	$5.70x10^{-2}$	HEAST	$2.00x10^{-1}$	IRIS
1,1-Dichloroethane	$1.40x10^{-1}$	HEAST	$1.00x10^{-1}$	HEAST
1,2-Dichloroethane	$1.40x10^{-3}$	NCEA	$3.00x10^{-2}$	NCEA
1,1-Dichloroethene	$2.00x10^{-2}$	Cal/EPA	$9.00x10^{-3}$	IRIS
cis-1,2-Dichloroethene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	HEAST
trans-1,2-Dichloroethene	$2.00x10^{-2}$	a	$2.00x10^{-2}$	IRIS
Ethylbenzene	$5.71x10^{-1}$	Cal/EPA	$1.00x10^{-1}$	IRIS
Fluorene	$4.00x10^{-2}$	a	$4.00x10^{-2}$	IRIS
2-Hexanone	NA		NA	
Isopropyl Benzene	$1.14x10^{-1}$	IRIS	$1.00x10^{-1}$	IRIS
4-Isopropyltoluene	NA		NA	
Methylene Chloride	$1.14x10^{-1}$	Cal/EPA	$6.00x10^{-2}$	IRIS
4-Methyl-2-Pentanone	$2.30x10^{-2}$	HEAST	$8.00x10^{-2}$	HEAST
Methyl tert-Butyl Ether	$2.29x10^{0}$	Cal/EPA	$3.00x10^{-2}$	EPA 1999
Naphthalene	$2.57x10^{-3}$	Cal/EPA	$2.00x10^{-2}$	IRIS
Phenanthrene	$8.57x10^{-4}$	a,c	$2.00x10^{-2}$	c
Pyrene	$3.00x10^{-2}$	a	$3.00x10^{-2}$	IRIS
n-Propylbenzene	$1.00x10^{-2}$	a	$1.00x10^{-2}$	NCEA
Styrene	$2.57x10^{-1}$	Cal/EPA	$2.00x10^{-1}$	IRIS
1,1,1,2-Tetrachloroethane	$3.00x10^{-2}$	a	$3.00x10^{-2}$	IRIS
Tetrachloroethene	$1.00x10^{-2}$	Cal/EPA	$1.00x10^{-2}$	IRIS
Toluene	$8.57x10^{-2}$	Cal/EPA	$2.00x10^{-1}$	IRIS
1,1,1-Trichloroethane	$2.90x10^{-1}$	NCEA	$2.00x10^{-2}$	NCEA
Trichloroethene	$1.71x10^{-1}$	Cal/EPA	$7.35x10^{-3}$	DTSC

Table 5-27 (Page 2 of 3)
Summary of Noncarcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values: Noncancer Reference Dose (RfD) mg/kg-d			
	Inhalation	Source	Oral	Source
Volatile Organic Compounds (continued)				
1,2,4-Trimethylbenzene	$1.70x10^{-3}$	NCEA	$5.00x10^{-2}$	NCEA
1,3,5-Trimethylbenzene	$1.70x10^{-3}$	NCEA	$5.00x10^{-2}$	NCEA
Vinyl Acetate	$5.71x10^{-2}$	Cal/EPA	$1.00x10^{0}$	HEAST
Vinyl Chloride	$2.90x10^{-2}$	IRIS	$3.00x10^{-3}$	IRIS
Xylenes (Total)	$2.00x10^{-1}$	Cal/EPA	$2.00x10^{0}$	IRIS
Semivolatile Organic Compounds				
Acenaphthylene	$8.57x10^{-4}$	a,c	$2.00x10^{-2}$	c
Benzo(a)anthracene	NA		NA	
Benzo(a)pyrene	NA		NA	
Benzo(b)fluoranthene	NA		NA	
Benzo(g,h,i)perylene	$8.57x10^{-4}$	c	$2.00x10^{-2}$	c
Benzo(k)fluoranthene	NA		NA	
Chrysene	NA		NA	
Dibenz(a,h)anthracene	NA		NA	
Fluoranthene	$4.00x10^{-2}$	a	$4.00x10^{-2}$	IRIS
Indeno(1,2,3-cd)pyrene	NA		NA	
Inorganic Compounds				
Aluminum	$1.40x10^{-3}$	NCEA	$1.00x10^{0}$	NCEA
Antimony	NA		$4.00x10^{-4}$	IRIS
Arsenic	$8.57x10^{-6}$	Cal/EPA	$3.00x10^{-4}$	IRIS
Barium	$1.40x10^{-4}$	HEAST	$7.00x10^{-2}$	IRIS
Beryllium	$2.00x10^{-6}$	Cal/EPA	$2.00x10^{-3}$	IRIS
Cadmium	$5.71x10^{-6}$	Cal/EPA	$5.00x10^{-4}$	IRIS
Chromium (III)	NA		$1.50x10^{0}$	IRIS
Chromium (VI)	$5.71x10^{-5}$	Cal/EPA	$3.00x10^{-3}$	IRIS
Cobalt	NA		$6.00x10^{-2}$	NCEA
Copper	NA		$3.70x10^{-2}$	HEAST
Magnesium	NA		NA	
Manganese	$5.71x10^{-5}$	Cal/EPA	$1.40x10^{-1}$	IRIS
Mercury	$2.57x10^{-5}$	Cal/EPA	$2.57x10^{-5}$	a
Molybdenum	NA		$5.00x10^{-3}$	HEAST
Nickel	$1.43x10^{-5}$	Cal/EPA	$2.00x10^{-2}$	IRIS
Selenium	$5.71x10^{-3}$	Cal/EPA	$5.00x10^{-3}$	IRIS
Silver	NA		$5.00x10^{-3}$	IRIS
Thallium	NA		$6.60x10^{-5}$	IRIS

Table 5-27 (Page 3 of 3)
Summary of Noncarcinogenic Toxicity Data - CalEPA Methodology

Chemical	Toxicity Values			
	Noncancer Reference Dose (RfD) mg/kg-d			
	Inhalation	Source	Oral	Source
Inorganic Compounds (continued)				
Vanadium	NA		$7.00x10^{-3}$	HEAST
Zinc	NA		$3.00x10^{-1}$	IRIS

NA denotes Not available

a - Based on route-to-route extrapolation, assuming equal absorption between the two routes.

b - Toxicity values for o-chlorotoluene were used as surrogates for 4-chlorotoluene.

c - Toxicity values for naphthalene were used as surrogates for acenaphthylene, benzo(g,h,i)perylene, and phenanthrene, because it has the lowest (most conservative) RfDs of the PAHs.

d - Toxicity value for nickel soluble salts used as a surrogate for nickel.

Sources:

California Environmental Protection Agency (Cal/EPA). 2001. Toxicity Criteria Database. Online database maintained by the Office of Environmental Health Hazard Assessment. http://www.oehha.org/risk.html

Department of Toxic Substances Control (DTSC). California Environmental Protection Agency. 1992. Trichloroethylene Reference Dose Value for Hillview-Porter Sites. Memorandum from Human and Ecological Risk Section to All Toxicologists. Sacramento, CA. July 13.

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United States Environmental Protection Agency (EPA). 1997. Health Effects Assessment Summary Tables (HEAST). FY 1997 Update. EPA 540-R-97-036. Office of Solid Waste and Emergency Response. Washington, D.C. July.

United States Environmental Protection Agency (EPA). 2000. Region 9 Preliminary Remediation Goals. San Francisco, CA. November 1.

United States Environmental Protection Agency (EPA). 2001. Integrated risk information system (IRIS). Online database maintained by the EPA. Cincinnati, OH.

The National Contingency Plan (40 Code of Federal Regulations 300) is commonly cited as the basis for acceptable incremental risk levels. According to the National Contingency Plan, lifetime incremental cancer risks posed by a site should not exceed one hundred in a million (1×10^{-4}) to one in a million (1×10^{-6}). For noncancer health hazards, a target HI of one is identified. Individual chemical exposures that yield HIs of greater than one may be of concern for noncancer health effects (EPA, 1989). Hazard indices for individual chemicals may be segregated based on target organ (e.g., liver, kidney, respiratory system), thus a cumulative HI for all chemicals that is greater than one may still indicate a safe exposure.

A summary of the cancer risks and noncancer HIs calculated in this risk assessment is presented in Tables 5-28 through 5-75 and is discussed below. Estimated cancer risks are expressed using scientific notation (e.g., 1×10^{-6}) and estimated HIs are expressed using decimal notation (e.g., 0.001). Results presented in the text are expressed using one significant figure. The use of one significant figure for reporting risk results is recommended by EPA (1989). Results prior to rounding are shown in the tables of results. Presentation of results prior to rounding is intended to facilitate the checking of the calculations by reviewers and to show the minor differences between the current and future scenarios prior to rounding.

5.9.2 Cancer Risks and Chronic Noncancer Hazard Indices for Current Residents

This section presents the results of the risk calculations for the current residents. Potential media of concern for these populations include surface soil, subsurface soil, and shallow groundwater. Section 5.9.2.1 discusses the estimated cancer and noncancer HIs for surface soil. Subsurface soil and groundwater are combined in Section 5.9.2.2 that discusses potential migration of VOCs into indoor air.

5.9.2.1 Surface Soil

As discussed in Section 5.5, current on-site residents could be exposed directly to PAHs and metals remaining in surface soil on site. Potential routes of exposure for these populations would include incidental ingestion, dermal contact, and inhalation of windblown particulates. The exposure duration for a current resident is six years. For current residents, the 0 to 0.5 feet bgs interval is the most likely depth for direct contact. In addition, both 0 to 2 feet bgs and 0 to 4 feet bgs were evaluated for potential contact during digging activities. Estimated cancer risks and noncancer HIs for direct current residential exposure to near surface soils is discussed below for PAHs and metals separately.

Polynuclear Aromatic Hydrocarbons. As discussed in Section 5.5, PAHs in soil were evaluated by decision area. The estimated cancer risks and noncancer HIs for potential current residential

exposure to PAHs in soil were summarized in Tables 5-28 through 5-35 by decision area, respectively. Tables 5-28, 5-30, 5-32, and 5-34 provide these results based on EPA methodology and Tables 5-29, 5-31, 5-33, and 5-35 provide these results based on CalEPA methodology. To calculate cancer risks, the chemical concentrations were converted to BaP-equivalent concentrations, as discussed in Section 3.0. The estimated HIs are presented by chemical and depth in Appendix C, Tables C2-1 through C2-28 (EPA methodology) and Tables C3-1 through C3-28 (CalEPA methodology). Each decision area is discussed separately below.

- For Area 1, the estimated cancer risk ranges from 5×10^{-6} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 1×10^{-5} (0 to 0.5 feet depth interval) for the EPA methodology and from 8×10^{-6} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 2×10^{-5} (0 to 0.5 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 2, the estimated cancer risk ranges from 2×10^{-5} (0 to 2 feet depth interval) to 5×10^{-5} (0 to 4 feet depth interval) for the EPA methodology and from 3×10^{-5} (0 to 2 feet depth interval) to 8×10^{-5} (0 to 4 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 3, the estimated cancer risk ranges from 9×10^{-6} (0 to 2 feet depth interval) to 1×10^{-5} (0 to 0.5 feet depth interval) for the EPA methodology and from 1×10^{-5} (0 to 4 feet depth interval) to 2×10^{-5} (0 to 0.5 feet depth interval and 0 to 2 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 4, the estimated cancer risk ranges from 3×10^{-5} (0 to 0.5 feet depth interval and 0 to 2 feet depth interval) to 4×10^{-5} (0 to 4 feet depth interval) for the EPA methodology and from 5×10^{-5} (0 to 0.5 feet depth interval and 0 to 2 feet depth interval) to 6×10^{-5} (0 to 4 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 5, the estimated cancer risk ranges from 3×10^{-5} (0 to 0.5 feet depth interval) to 5×10^{-5} (0 to 4 feet depth interval) for the EPA methodology and from 4×10^{-5} (0 to 0.5 feet depth interval) to 6×10^{-5} (0 to 4 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 6, the estimated cancer risk ranges from 1×10^{-5} (0 to 0.5 feet depth interval) to 3×10^{-5} (0 to 4 feet depth interval) for the EPA methodology and from 2×10^{-5} (0 to 0.5 feet depth interval) to 5×10^{-5} (0 to 4 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

Table 5-28
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbon in Soil - Current Residents - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk							
			Current Adult Resident				Current Child Resident			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	1.04	$5.8x10^{-11}$	$8.9x10^{-7}$	$4.6x10^{-7}$	**$1x10^{-6}$**	$1.3x10^{-10}$	$8.3x10^{-6}$	$3.0x10^{-6}$	**$1x10^{-5}$**
1	0-2.0	0.48	$2.6x10^{-11}$	$4.1x10^{-7}$	$2.1x10^{-7}$	**$6x10^{-7}$**	$6.2x10^{-11}$	$3.8x10^{-6}$	$1.4x10^{-6}$	**$5x10^{-6}$**
1	0-4.0	0.49	$2.7x10^{-11}$	$4.2x10^{-7}$	$2.2x10^{-7}$	**$6x10^{-7}$**	$6.3x10^{-11}$	$3.9x10^{-6}$	$1.4x10^{-6}$	**$5x10^{-6}$**
2	0-0.5	2.84	$1.6x10^{-10}$	$2.4x10^{-6}$	$1.3x10^{-6}$	**$4x10^{-6}$**	$3.7x10^{-10}$	$2.3x10^{-5}$	$8.3x10^{-6}$	**$3x10^{-5}$**
2	0-2.0	1.98	$1.1x10^{-10}$	$1.7x10^{-6}$	$8.8x10^{-7}$	**$3x10^{-6}$**	$2.6x10^{-10}$	$1.6x10^{-5}$	$5.8x10^{-6}$	**$2x10^{-5}$**
2	0-4.0	4.54	$2.5x10^{-10}$	$3.9x10^{-6}$	$2.0x10^{-6}$	**$6x10^{-6}$**	$5.9x10^{-10}$	$3.6x10^{-5}$	$1.3x10^{-5}$	**$5x10^{-5}$**
3	0-0.5	1.15	$6.4x10^{-11}$	$9.8x10^{-7}$	$5.1x10^{-7}$	**$1x10^{-6}$**	$1.5x10^{-10}$	$9.2x10^{-6}$	$3.3x10^{-6}$	**$1x10^{-5}$**
3	0-2.0	0.79	$4.4x10^{-11}$	$6.8x10^{-7}$	$3.5x10^{-7}$	**$1x10^{-6}$**	$1.0x10^{-10}$	$6.3x10^{-6}$	$2.3x10^{-6}$	**$9x10^{-6}$**
3	0-4.0	0.74	$4.1x10^{-11}$	$6.3x10^{-7}$	$3.3x10^{-7}$	**$1x10^{-6}$**	$9.5x10^{-11}$	$5.9x10^{-6}$	$2.1x10^{-6}$	**$8x10^{-6}$**
4	0-0.5	3.04	$1.7x10^{-10}$	$2.6x10^{-6}$	$1.4x10^{-6}$	**$4x10^{-6}$**	$3.9x10^{-10}$	$2.4x10^{-5}$	$8.8x10^{-6}$	**$3x10^{-5}$**
4	0-2.0	3.03	$1.7x10^{-10}$	$2.6x10^{-6}$	$1.3x10^{-6}$	**$4x10^{-6}$**	$3.9x10^{-10}$	$2.4x10^{-5}$	$8.8x10^{-6}$	**$3x10^{-5}$**
4	0-4.0	3.85	$2.1x10^{-10}$	$3.3x10^{-6}$	$1.7x10^{-6}$	**$5x10^{-6}$**	$5.0x10^{-10}$	$3.1x10^{-5}$	$1.1x10^{-5}$	**$4x10^{-5}$**
5	0-0.5	2.97	$1.6x10^{-10}$	$2.5x10^{-6}$	$1.3x10^{-6}$	**$4x10^{-6}$**	$3.8x10^{-10}$	$2.4x10^{-5}$	$8.6x10^{-6}$	**$3x10^{-5}$**
5	0-2.0	3.47	$1.9x10^{-10}$	$3.0x10^{-6}$	$1.5x10^{-6}$	**$5x10^{-6}$**	$4.5x10^{-10}$	$2.8x10^{-5}$	$1.0x10^{-5}$	**$4x10^{-5}$**
5	0-4.0	4.22	$2.3x10^{-10}$	$3.6x10^{-6}$	$1.9x10^{-6}$	**$5x10^{-6}$**	$5.4x10^{-10}$	$3.4x10^{-5}$	$1.2x10^{-5}$	**$5x10^{-5}$**
6	0-0.5	1.33	$7.4x10^{-11}$	$1.1x10^{-6}$	$5.9x10^{-7}$	**$2x10^{-6}$**	$1.7x10^{-10}$	$1.1x10^{-5}$	$3.9x10^{-6}$	**$1x10^{-5}$**
6	0-2.0	1.87	$1.0x10^{-10}$	$1.6x10^{-6}$	$8.3x10^{-7}$	**$2x10^{-6}$**	$2.4x10^{-10}$	$1.5x10^{-5}$	$5.4x10^{-6}$	**$2x10^{-5}$**
6	0-4.0	3.02	$1.7x10^{-10}$	$2.6x10^{-6}$	$1.3x10^{-6}$	**$4x10^{-6}$**	$3.9x10^{-10}$	$2.4x10^{-5}$	$8.8x10^{-6}$	**$3x10^{-5}$**
7	0-0.5	9.63	$5.3x10^{-10}$	$8.3x10^{-6}$	$4.3x10^{-6}$	**$1x10^{-5}$**	$1.2x10^{-9}$	$7.7x10^{-5}$	$2.8x10^{-5}$	**$1x10^{-4}$**
7	0-2.0	7.18	$4.0x10^{-10}$	$6.2x10^{-6}$	$3.2x10^{-6}$	**$9x10^{-6}$**	$9.3x10^{-10}$	$5.7x10^{-5}$	$2.1x10^{-5}$	**$8x10^{-5}$**
7	0-4.0	6.49	$3.6x10^{-10}$	$5.6x10^{-6}$	$2.9x10^{-6}$	**$8x10^{-6}$**	$8.4x10^{-10}$	$5.2x10^{-5}$	$1.9x10^{-5}$	**$7x10^{-5}$**

mg/kg denotes milligrams per kilogram

Table 5-29
Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbon in Soil - Current Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk							
			Current Adult Resident				Current Child Resident			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	$1.01x10^{0}$	$7.1x10^{-11}$	$1.4x10^{-6}$	$7.4x10^{-7}$	**$2x10^{-6}$**	$1.6x10^{-10}$	$1.3x10^{-5}$	$5.0x10^{-6}$	**$2x10^{-5}$**
1	0-2.0	$4.38x10^{-1}$	$3.0x10^{-11}$	$6.2x10^{-7}$	$3.2x10^{-7}$	**$9x10^{-7}$**	$7.1x10^{-11}$	$5.8x10^{-6}$	$2.2x10^{-6}$	**$8x10^{-6}$**
1	0-4.0	$4.58x10^{-1}$	$3.2x10^{-11}$	$6.5x10^{-7}$	$3.3x10^{-7}$	**$1x10^{-6}$**	$7.4x10^{-11}$	$6.0x10^{-6}$	$2.3x10^{-6}$	**$8x10^{-6}$**
2	0-0.5	$2.35x10^{0}$	$1.6x10^{-10}$	$3.3x10^{-6}$	$1.7x10^{-6}$	**$5x10^{-6}$**	$3.8x10^{-10}$	$3.1x10^{-5}$	$1.2x10^{-5}$	**$4x10^{-5}$**
2	0-2.0	$1.71x10^{0}$	$1.2x10^{-10}$	$2.4x10^{-6}$	$1.3x10^{-6}$	**$4x10^{-6}$**	$2.8x10^{-10}$	$2.3x10^{-5}$	$8.5x10^{-6}$	**$3x10^{-5}$**
2	0-4.0	$4.20x10^{0}$	$2.9x10^{-10}$	$5.9x10^{-6}$	$3.1x10^{-6}$	**$9x10^{-6}$**	$6.8x10^{-10}$	$5.5x10^{-5}$	$2.1x10^{-5}$	**$8x10^{-5}$**
3	0-0.5	$1.20x10^{0}$	$8.4x10^{-11}$	$1.7x10^{-6}$	$8.8x10^{-7}$	**$3x10^{-6}$**	$1.9x10^{-10}$	$1.6x10^{-5}$	$6.0x10^{-6}$	**$2x10^{-5}$**
3	0-2.0	$8.38x10^{-1}$	$5.8x10^{-11}$	$1.2x10^{-6}$	$6.1x10^{-7}$	**$2x10^{-6}$**	$1.4x10^{-10}$	$1.1x10^{-5}$	$4.2x10^{-6}$	**$2x10^{-5}$**
3	0-4.0	$7.31x10^{-1}$	$5.1x10^{-11}$	$1.0x10^{-6}$	$5.3x10^{-7}$	**$2x10^{-6}$**	$1.2x10^{-10}$	$9.6x10^{-6}$	$3.6x10^{-6}$	**$1x10^{-5}$**
4	0-0.5	$2.57x10^{0}$	$1.8x10^{-10}$	$3.6x10^{-6}$	$1.9x10^{-6}$	**$5x10^{-6}$**	$4.2x10^{-10}$	$3.4x10^{-5}$	$1.3x10^{-5}$	**$5x10^{-5}$**
4	0-2.0	$2.63x10^{0}$	$1.8x10^{-10}$	$3.7x10^{-6}$	$1.9x10^{-6}$	**$6x10^{-6}$**	$4.3x10^{-10}$	$3.5x10^{-5}$	$1.3x10^{-5}$	**$5x10^{-5}$**
4	0-4.0	$3.24x10^{0}$	$2.3x10^{-10}$	$4.6x10^{-6}$	$2.4x10^{-6}$	**$7x10^{-6}$**	$5.3x10^{-10}$	$4.3x10^{-5}$	$1.6x10^{-5}$	**$6x10^{-5}$**
5	0-0.5	$2.47x10^{0}$	$1.7x10^{-10}$	$3.5x10^{-6}$	$1.8x10^{-6}$	**$5x10^{-6}$**	$4.0x10^{-10}$	$3.2x10^{-5}$	$1.2x10^{-5}$	**$4x10^{-5}$**
5	0-2.0	$2.92x10^{0}$	$2.0x10^{-10}$	$4.1x10^{-6}$	$2.1x10^{-6}$	**$6x10^{-6}$**	$4.7x10^{-10}$	$3.8x10^{-5}$	$1.4x10^{-5}$	**$5x10^{-5}$**
5	0-4.0	$3.58x10^{0}$	$2.5x10^{-10}$	$5.0x10^{-6}$	$2.6x10^{-6}$	**$8x10^{-6}$**	$5.8x10^{-10}$	$4.7x10^{-5}$	$1.8x10^{-5}$	**$6x10^{-5}$**
6	0-0.5	$1.20x10^{0}$	$8.4x10^{-11}$	$1.7x10^{-6}$	$8.8x10^{-7}$	**$3x10^{-6}$**	$2.0x10^{-10}$	$1.6x10^{-5}$	$6.0x10^{-6}$	**$2x10^{-5}$**
6	0-2.0	$1.64x10^{0}$	$1.1x10^{-10}$	$2.3x10^{-6}$	$1.2x10^{-6}$	**$4x10^{-6}$**	$2.7x10^{-10}$	$2.2x10^{-5}$	$8.1x10^{-6}$	**$3x10^{-5}$**
6	0-4.0	$2.63x10^{0}$	$1.8x10^{-10}$	$3.7x10^{-6}$	$1.9x10^{-6}$	**$6x10^{-6}$**	$4.3x10^{-10}$	$3.5x10^{-5}$	$1.3x10^{-5}$	**$5x10^{-5}$**
7	0-0.5	$7.26x10^{0}$	$5.1x10^{-10}$	$1.0x10^{-5}$	$5.3x10^{-6}$	**$2x10^{-5}$**	$1.2x10^{-9}$	$9.6x10^{-5}$	$3.6x10^{-5}$	**$1x10^{-4}$**
7	0-2.0	$5.98x10^{0}$	$4.2x10^{-10}$	$8.4x10^{-6}$	$4.4x10^{-6}$	**$1x10^{-5}$**	$9.7x10^{-10}$	$7.9x10^{-5}$	$3.0x10^{-5}$	**$1x10^{-4}$**
7	0-4.0	$5.67x10^{0}$	$3.9x10^{-10}$	$8.0x10^{-6}$	$4.1x10^{-6}$	**$1x10^{-5}$**	$9.2x10^{-10}$	$7.5x10^{-5}$	$2.8x10^{-5}$	**$1x10^{-4}$**

mg/kg denotes milligrams per kilogram

Table 5-30 (Page 1 of 2)
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	1.04	$3.6x10^{-10}$	$1.2x10^{-5}$	$4.9x10^{-6}$	$2x10^{-5}$
1	0-2.0	0.48	$1.7x10^{-10}$	$5.5x10^{-6}$	$2.2x10^{-6}$	$8x10^{-6}$
1	0-4.0	0.49	$1.7x10^{-10}$	$5.6x10^{-6}$	$2.3x10^{-6}$	$8x10^{-6}$
1	0-8.0	0.78	$2.7x10^{-10}$	$8.9x10^{-6}$	$3.7x10^{-6}$	$1x10^{-5}$
2	0-0.5	2.84	$9.9x10^{-10}$	$3.2x10^{-5}$	$1.3x10^{-5}$	$5x10^{-5}$
2	0-2.0	1.98	$6.9x10^{-10}$	$2.3x10^{-5}$	$9.3x10^{-6}$	$3x10^{-5}$
2	0-4.0	4.54	$1.6x10^{-9}$	$5.2x10^{-5}$	$2.1x10^{-5}$	$7x10^{-5}$
2	0-8.0	9.62	$3.4x10^{-9}$	$1.1x10^{-4}$	$4.5x10^{-5}$	$2x10^{-4}$
3	0-0.5	1.15	$4.0x10^{-10}$	$1.3x10^{-5}$	$5.4x10^{-6}$	$2x10^{-5}$
3	0-2.0	0.79	$2.8x10^{-10}$	$9.1x10^{-6}$	$3.7x10^{-6}$	$1x10^{-5}$
3	0-4.0	0.74	$2.6x10^{-10}$	$8.4x10^{-6}$	$3.5x10^{-6}$	$1x10^{-5}$
3	0-8.0	11.78	$4.1x10^{-9}$	$1.3x10^{-4}$	$5.5x10^{-5}$	$2x10^{-4}$
4	0-0.5	3.04	$1.1x10^{-9}$	$3.5x10^{-5}$	$1.4x10^{-5}$	$5x10^{-5}$
4	0-2.0	3.03	$1.1x10^{-9}$	$3.5x10^{-5}$	$1.4x10^{-5}$	$5x10^{-5}$
4	0-4.0	3.85	$1.3x10^{-9}$	$4.4x10^{-5}$	$1.8x10^{-5}$	$6x10^{-5}$
4	0-8.0	5.19	$1.8x10^{-9}$	$5.9x10^{-5}$	$2.4x10^{-5}$	$8x10^{-5}$
5	0-0.5	2.97	$1.0x10^{-9}$	$3.4x10^{-5}$	$1.4x10^{-5}$	$5x10^{-5}$
5	0-2.0	3.47	$1.2x10^{-9}$	$4.0x10^{-5}$	$1.6x10^{-5}$	$6x10^{-5}$
5	0-4.0	4.22	$1.5x10^{-9}$	$4.8x10^{-5}$	$2.0x10^{-5}$	$7x10^{-5}$
5	0-8.0	2.75	$9.6x10^{-10}$	$3.1x10^{-5}$	$1.3x10^{-5}$	$4x10^{-5}$
6	0-0.5	1.33	$4.7x10^{-10}$	$1.5x10^{-5}$	$6.2x10^{-6}$	$2x10^{-5}$
6	0-2.0	1.87	$6.5x10^{-10}$	$2.1x10^{-5}$	$8.7x10^{-6}$	$3x10^{-5}$
6	0-4.0	3.02	$1.1x10^{-9}$	$3.5x10^{-5}$	$1.4x10^{-5}$	$5x10^{-5}$
6	0-8.0	15.29	$5.4x10^{-9}$	$1.7x10^{-4}$	$7.2x10^{-5}$	$2x10^{-4}$

Table 5-30 (Page 2 of 2)
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
7	0-0.5	9.63	$3.4x10^{-9}$	$1.1x10^{-4}$	$4.5x10^{-5}$	$2x10^{-4}$
7	0-2.0	7.18	$2.5x10^{-9}$	$8.2x10^{-5}$	$3.4x10^{-5}$	$1x10^{-4}$
7	0-4.0	6.49	$2.3x10^{-9}$	$7.4x10^{-5}$	$3.0x10^{-5}$	$1x10^{-4}$
7	0-8.0	77.35	$2.7x10^{-8}$	$8.8x10^{-4}$	$3.6x10^{-4}$	$1x10^{-3}$

mg/kg denotes milligrams per kilogram

Table 5-31 (Page 1 of 2)
Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	1.01	$4.5x10^{-10}$	$1.9x10^{-5}$	$8.0x10^{-6}$	$3x10^{-5}$
1	0-2.0	0.44	$1.9x10^{-10}$	$8.2x10^{-6}$	$3.5x10^{-6}$	$1x10^{-5}$
1	0-4.0	0.46	$2.0x10^{-10}$	$8.6x10^{-6}$	$3.6x10^{-6}$	$1x10^{-5}$
1	0-8.0	0.61	$2.7x10^{-10}$	$1.1x10^{-5}$	$4.8x10^{-6}$	$2x10^{-5}$
2	0-0.5	2.35	$1.0x10^{-9}$	$4.4x10^{-5}$	$1.9x10^{-5}$	$6x10^{-5}$
2	0-2.0	1.71	$7.5x10^{-10}$	$3.2x10^{-5}$	$1.3x10^{-5}$	$5x10^{-5}$
2	0-4.0	4.20	$1.9x10^{-9}$	$7.9x10^{-5}$	$3.3x10^{-5}$	$1x10^{-4}$
2	0-8.0	8.11	$3.6x10^{-9}$	$1.5x10^{-4}$	$6.4x10^{-5}$	$2x10^{-4}$
3	0-0.5	1.20	$5.3x10^{-10}$	$2.3x10^{-5}$	$9.5x10^{-6}$	$3x10^{-5}$
3	0-2.0	0.84	$3.7x10^{-10}$	$1.6x10^{-5}$	$6.6x10^{-6}$	$2x10^{-5}$
3	0-4.0	0.73	$3.2x10^{-10}$	$1.4x10^{-5}$	$5.8x10^{-6}$	$2x10^{-5}$
3	0-8.0	11.31	$5.0x10^{-9}$	$2.1x10^{-4}$	$8.9x10^{-5}$	$3x10^{-4}$
4	0-0.5	2.57	$1.1x10^{-9}$	$4.8x10^{-5}$	$2.0x10^{-5}$	$7x10^{-5}$
4	0-2.0	2.63	$1.2x10^{-9}$	$4.9x10^{-5}$	$2.1x10^{-5}$	$7x10^{-5}$
4	0-4.0	3.24	$1.4x10^{-9}$	$6.1x10^{-5}$	$2.6x10^{-5}$	$9x10^{-5}$
4	0-8.0	4.36	$1.9x10^{-9}$	$8.2x10^{-5}$	$3.4x10^{-5}$	$1x10^{-4}$
5	0-0.5	2.47	$1.1x10^{-9}$	$4.6x10^{-5}$	$1.9x10^{-5}$	$7x10^{-5}$
5	0-2.0	2.92	$1.3x10^{-9}$	$5.5x10^{-5}$	$2.3x10^{-5}$	$8x10^{-5}$
5	0-4.0	3.58	$1.6x10^{-9}$	$6.7x10^{-5}$	$2.8x10^{-5}$	$1x10^{-4}$
5	0-8.0	2.40	$1.1x10^{-9}$	$4.5x10^{-5}$	$1.9x10^{-5}$	$6x10^{-5}$

Table 5-31 (Page 2 of 2)
Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
6	0-0.5	1.20	$5.3x10^{-10}$	$2.3x10^{-5}$	$9.5x10^{-6}$	$3x10^{-5}$
6	0-2.0	1.64	$7.2x10^{-10}$	$3.1x10^{-5}$	$1.3x10^{-5}$	$4x10^{-5}$
6	0-4.0	2.63	$1.2x10^{-9}$	$4.9x10^{-5}$	$2.1x10^{-5}$	$7x10^{-5}$
6	0-8.0	11.85	$5.2x10^{-9}$	$2.2x10^{-4}$	$9.3x10^{-5}$	$3x10^{-4}$
7	0-0.5	7.26	$3.2x10^{-9}$	$1.4x10^{-4}$	$5.7x10^{-5}$	$2x10^{-4}$
7	0-2.0	5.98	$2.6x10^{-9}$	$1.1x10^{-4}$	$4.7x10^{-5}$	$2x10^{-4}$
7	0-4.0	5.67	$2.5x10^{-9}$	$1.1x10^{-4}$	$4.5x10^{-5}$	$2x10^{-4}$
7	0-8.0	74.79	$3.3x10^{-8}$	$1.4x10^{-3}$	$5.9x10^{-4}$	$2x10^{-3}$

mg/kg denotes milligrams per kilogram
bgs denotes below ground surface

Table 5-32
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Construction Workers - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
All of Parcel 181	**0-8.0**	10.43	3.1×10^{-8}	2.6×10^{-6}	4.6×10^{-7}	**3×10^{-6}**
Northern Parcel	**0-8.0**	19.51	5.9×10^{-8}	4.8×10^{-6}	8.5×10^{-7}	**6×10^{-6}**
Southern Parcel	**0-8.0**	2.64	7.9×10^{-9}	6.5×10^{-7}	1.2×10^{-7}	**8×10^{-7}**

mg/kg denotes milligrams per kilogram

Table 5-33
Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Construction Workers - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
All of Parcel 181	**0-8.0**	8.91	$3.4x10^{-8}$	$3.6x10^{-6}$	$5.1x10^{-6}$	**$9x10^{-6}$**
Northern Parcel 181	**0-8.0**	17.96	$6.8x10^{-8}$	$7.2x10^{-6}$	$1.0x10^{-5}$	**$2x10^{-5}$**
Southern Parcel 181	**0-8.0**	2.17	$8.2x10^{-9}$	$8.7x10^{-7}$	$1.2x10^{-6}$	**$2x10^{-6}$**

mg/kg denotes milligrams per kilogram

Table 5-34
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Current Residents - EPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index							
		Current Adult Resident				Current Child Resident			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	$3x10^{-7}$	0.0003	0.0001	**0.0004**	$8x10^{-7}$	0.002	0.0009	**0.003**
1	0-2.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-4.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
2	0-0.5	$8x10^{-7}$	0.0005	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-2.0	$7x10^{-7}$	0.0004	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.001	**0.005**
2	0-4.0	$1x10^{-6}$	0.0009	0.0005	**0.001**	$3x10^{-6}$	0.009	0.003	**0.01**
3	0-0.5	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0008	**0.003**
3	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0006	**0.002**
3	0-4.0	$2x10^{-7}$	0.0001	0.00007	**0.0002**	$5x10^{-7}$	0.001	0.0005	**0.002**
4	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
4	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0006	**0.002**
4	0-4.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
5	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
5	0-2.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-4.0	$1x10^{-6}$	0.0009	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
6	0-0.5	$5x10^{-7}$	0.0003	0.0001	**0.0004**	$1x10^{-6}$	0.003	0.0009	**0.003**
6	0-2.0	$6x10^{-7}$	0.0004	0.0002	**0.0005**	$1x10^{-6}$	0.003	0.001	**0.005**
6	0-4.0	$1x10^{-6}$	0.0006	0.0003	**0.0009**	$2x10^{-6}$	0.006	0.002	**0.008**
7	0-0.5	$5x10^{-6}$	0.003	0.002	**0.004**	$1x10^{-5}$	0.03	0.01	**0.04**
7	0-2.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.006	**0.02**
7	0-4.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.006	**0.02**

Table 5-35
Summary of Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Current Residents - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index							
		Current Adult Resident				Current Child Resident			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	$3x10^{-7}$	0.0003	0.0001	**0.0004**	$8x10^{-7}$	0.002	0.0009	**0.003**
1	0-2.0	$2x10^{-7}$	0.0001	0.00005	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-4.0	$2x10^{-7}$	0.0001	0.00005	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
2	0-0.5	$7x10^{-7}$	0.0005	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-2.0	$7x10^{-7}$	0.0004	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-4.0	$1x10^{-6}$	0.0009	0.0005	**0.001**	$3x10^{-6}$	0.009	0.003	**0.01**
3	0-0.5	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$6x10^{-7}$	0.002	0.0008	**0.003**
3	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0007	**0.002**
3	0-4.0	$2x10^{-7}$	0.0001	0.00007	**0.0002**	$5x10^{-7}$	0.001	0.0005	**0.002**
4	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.009**
4	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0007	**0.002**
4	0-4.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.009**
5	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.009**
5	0-2.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-4.0	$1x10^{-6}$	0.0009	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
6	0-0.5	$4x10^{-7}$	0.0003	0.0001	**0.0004**	$1x10^{-6}$	0.003	0.0009	**0.003**
6	0-2.0	$6x10^{-7}$	0.0004	0.0002	**0.0005**	$1x10^{-6}$	0.003	0.001	**0.005**
6	0-4.0	$1x10^{-6}$	0.0006	0.0003	**0.0009**	$2x10^{-6}$	0.006	0.002	**0.008**
7	0-0.5	$4x10^{-6}$	0.003	0.002	**0.004**	$9x10^{-6}$	0.03	0.01	**0.04**
7	0-2.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.007	**0.02**
7	0-4.0	$3x10^{-6}$	0.002	0.001	**0.003**	$6x10^{-6}$	0.02	0.006	**0.02**

Table 5-36
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index							
		Future Adult Resident				Future Child Resident			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	$3x10^{-7}$	0.0003	0.0001	**0.0004**	$8x10^{-7}$	0.002	0.0009	**0.003**
1	0-2.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-4.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-8.0	$2x10^{-7}$	0.0001	$6x10^{-5}$	**0.0002**	$5x10^{-7}$	0.001	0.000	**0.002**
2	0-0.5	$8x10^{-7}$	0.0005	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-2.0	$7x10^{-7}$	0.0004	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.001	**0.005**
2	0-4.0	$1x10^{-6}$	0.0009	0.0005	**0.001**	$3x10^{-6}$	0.009	0.003	**0.01**
2	0-8.0	$4x10^{-6}$	0.002	0.001	**0.004**	$9x10^{-6}$	0.02	0.01	**0.03**
3	0-0.5	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0008	**0.003**
3	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0006	**0.002**
3	0-4.0	$2x10^{-7}$	0.0001	0.00007	**0.0002**	$5x10^{-7}$	0.001	0.0005	**0.002**
3	0-8.0	$2x10^{-6}$	0.001	0.0006	**0.002**	$5x10^{-6}$	0.01	0.004	**0.02**
4	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
4	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.0006	**0.002**
4	0-4.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
4	0-8.0	$3x10^{-6}$	0.002	0.0009	**0.003**	$6x10^{-6}$	0.02	0.006	**0.02**
5	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.002	**0.009**
5	0-2.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-4.0	$1x10^{-6}$	0.0009	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-8.0	$9x10^{-7}$	0.0007	0.0004	**0.001**	$2x10^{-6}$	0.006	0.002	**0.009**
6	0-0.5	$5x10^{-7}$	0.0003	0.0001	**0.0004**	$1x10^{-6}$	0.003	0.0009	**0.003**
6	0-2.0	$6x10^{-7}$	0.0004	0.0002	**0.0005**	$1x10^{-6}$	0.003	0.001	**0.005**
6	0-4.0	$1x10^{-6}$	0.0006	0.0003	**0.0009**	$2x10^{-6}$	0.006	0.002	**0.008**
6	0-8.0	$5x10^{-6}$	0.003	0.002	**0.005**	$1x10^{-5}$	0.03	0.01	**0.04**
7	0-0.5	$5x10^{-6}$	0.003	0.002	**0.004**	$1x10^{-5}$	0.03	0.01	**0.04**
7	0-2.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.006	**0.02**
7	0-4.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.006	**0.02**
7	0-8.0	0.0001	0.06	0.03	**0.08**	0.0003	0.5	0.2	**0.7**

Table 5-37
Summary of Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Future Residents - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index							
		Future Adult Resident				Future Child Resident			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
1	0-0.5	$3x10^{-7}$	0.0003	0.0001	**0.0004**	$8x10^{-7}$	0.002	0.001	**0.003**
1	0-2.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-4.0	$2x10^{-7}$	0.0001	$5x10^{-5}$	**0.0002**	$4x10^{-7}$	0.001	0.0004	**0.001**
1	0-8.0	$2x10^{-7}$	0.0001	0.0001	**0.0002**	$4x10^{-7}$	0.001	0.000	**0.002**
2	0-0.5	$7x10^{-7}$	0.0005	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-2.0	$7x10^{-7}$	0.0004	0.0002	**0.0007**	$2x10^{-6}$	0.004	0.002	**0.006**
2	0-4.0	$1x10^{-6}$	0.001	0.0005	**0.001**	$3x10^{-6}$	0.009	0.003	**0.01**
2	0-8.0	$4x10^{-6}$	0.002	0.001	**0.004**	$9x10^{-6}$	0.02	0.01	**0.03**
3	0-0.5	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$6x10^{-7}$	0.002	0.001	**0.003**
3	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.0003**	$7x10^{-7}$	0.002	0.001	**0.002**
3	0-4.0	$2x10^{-7}$	0.0001	0.00007	**0.0002**	$5x10^{-7}$	0.001	0.0005	**0.002**
3	0-8.0	$2x10^{-6}$	0.001	0.0006	**0.002**	$5x10^{-6}$	0.01	0.004	**0.02**
4	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.01**
4	0-2.0	$3x10^{-7}$	0.0002	0.0001	**0.000**	$7x10^{-7}$	0.002	0.001	**0.002**
4	0-4.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.01**
4	0-8.0	$3x10^{-6}$	0.002	0.001	**0.003**	$6x10^{-6}$	0.02	0.006	**0.02**
5	0-0.5	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.007	0.003	**0.01**
5	0-2.0	$1x10^{-6}$	0.0007	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-4.0	$1x10^{-6}$	0.0009	0.0004	**0.001**	$3x10^{-6}$	0.001	0.0004	**0.001**
5	0-8.0	$9x10^{-7}$	0.0007	0.0004	**0.001**	$2x10^{-6}$	0.006	0.002	**0.01**
6	0-0.5	$4x10^{-7}$	0.0003	0.0001	**0.0004**	$1x10^{-6}$	0.003	0.001	**0.003**
6	0-2.0	$6x10^{-7}$	0.0004	0.0002	**0.0005**	$1x10^{-6}$	0.003	0.001	**0.005**
6	0-4.0	$1x10^{-6}$	0.0006	0.0003	**0.001**	$2x10^{-6}$	0.006	0.002	**0.008**
6	0-8.0	$5x10^{-6}$	0.003	0.002	**0.005**	$1x10^{-5}$	0.03	0.01	**0.04**
7	0-0.5	$4x10^{-6}$	0.003	0.002	**0.004**	$9x10^{-6}$	0.03	0.01	**0.04**
7	0-2.0	$3x10^{-6}$	0.002	0.001	**0.003**	$7x10^{-6}$	0.02	0.01	**0.02**
7	0-4.0	$3x10^{-6}$	0.002	0.001	**0.003**	$6x10^{-6}$	0.02	0.01	**0.02**
7	0-8.0	0.0001	0.06	0.03	**0.08**	0.0002	0.5	0.2	**0.7**

Table 5-38
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Construction Workers - EPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
All of Parcel 181	0-8.0	0.002	0.006	0.001	**0.009**
Northern Parcel	0-8.0	0.007	0.02	0.003	**0.03**
Southern Parcel	0-8.0	0.0003	0.001	0.0002	**0.001**

Table 5-39
Summary of Pathway-Specific Noncancer Hazard Indices for Polynuclear Aromatic Hydrocarbons in Soil - Construction Workers - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Noncancer Hazard Index			
		Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
All of Parcel 181	0-8.0	0.002	0.006	0.008	**0.02**
Northern Parcel 181	0-8.0	0.007	0.02	0.026	**0.05**
Southern Parcel 181	0-8.0	0.0003	0.001	0.0014	**0.003**

Table 5-40
Summary of Estimated Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Current Residents - EPA Methodology

Depth Interval (feet)	Estimated Cancer Risk							
	Current Adult Resident				Current Child Resident			
	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	7.1×10^{-9}	7.2×10^{-7}	8.7×10^{-8}	**8×10^{-7}**	1.7×10^{-8}	6.8×10^{-6}	5.7×10^{-7}	**7×10^{-6}**
0-2.0	6.7×10^{-9}	7.2×10^{-7}	8.6×10^{-8}	**8×10^{-7}**	1.6×10^{-8}	6.7×10^{-6}	5.6×10^{-7}	**7×10^{-6}**
0-4.0	8.1×10^{-9}	8.0×10^{-7}	9.6×10^{-8}	**9×10^{-7}**	1.9×10^{-8}	7.5×10^{-6}	6.3×10^{-7}	**8×10^{-6}**

Table 5-41
Summary of Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Current Residents - CalEPA Methodology

Depth Interval (feet bgs)	Estimated Cancer Risk							
	Current Adult Resident				Current Child Resident			
	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	$5.9x10^{-8}$	$7.4x10^{-7}$	$8.7x10^{-8}$	**$9x10^{-7}$**	$1.4x10^{-7}$	$6.9x10^{-6}$	$5.9x10^{-7}$	**$8x10^{-6}$**
0-2.0	$5.5x10^{-8}$	$7.3x10^{-7}$	$8.6x10^{-8}$	**$9x10^{-7}$**	$1.3x10^{-7}$	$6.8x10^{-6}$	$5.8x10^{-7}$	**$8x10^{-6}$**
0-4.0	$6.7x10^{-8}$	$8.2x10^{-7}$	$9.6x10^{-8}$	**$1x10^{-6}$**	$1.6x10^{-7}$	$7.6x10^{-6}$	$6.5x10^{-7}$	**$8x10^{-6}$**

bgs denotes below ground surface

Table 5-42
Summary of Estimated Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Future Residents - EPA Methodology

	Estimated Cancer Risk			
	Future Resident (age-adjusted)			
Depth Interval (feet)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	$4.5x10^{-8}$	$9.7x10^{-6}$	$9.1x10^{-7}$	**$1x10^{-5}$**
0-2.0	$4.3x10^{-8}$	$9.6x10^{-6}$	$9.1x10^{-7}$	**$1x10^{-5}$**
0-4.0	$5.2x10^{-8}$	$1.1x10^{-5}$	$1.0x10^{-6}$	**$1x10^{-5}$**
0-8.0	$5.5x10^{-8}$	$1.0x10^{-5}$	$9.4x10^{-7}$	**$1x10^{-5}$**

Table 5-43
Summary of Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Future Residents - CalEPA Methodology

	Estimated Cancer Risk			
	Future Resident (age-adjusted)			
Depth Interval (feet bgs)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	3.7×10^{-7}	9.8×10^{-6}	9.4×10^{-7}	$\mathbf{1 \times 10^{-5}}$
0-2.0	3.5×10^{-7}	9.7×10^{-6}	9.3×10^{-7}	$\mathbf{1 \times 10^{-5}}$
0-4.0	4.2×10^{-7}	1.1×10^{-5}	1.0×10^{-6}	$\mathbf{1 \times 10^{-5}}$
0-8.0	4.6×10^{-7}	1.0×10^{-5}	9.6×10^{-7}	$\mathbf{1 \times 10^{-5}}$

bgs denotes below ground surface

Table 5-44
Summary of Estimated Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Construction Workers - EPA Methodology

	Estimated Cancer Risk			
Depth Interval (feet)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-8.0	4.7×10^{-7}	2.1×10^{-7}	8.8×10^{-9}	**7×10^{-7}**

Table 5-45
Summary of Pathway-Specific Cancer Risks for Inorganic Chemicals in Soil - Construction Workers - CalEPA Methodology

	Estimated Cancer Risk			
Depth Interval (feet bgs)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-8.0	3.9×10^{-6}	2.2×10^{-7}	6.1×10^{-8}	4×10^{-6}

bgs denotes below ground surface

Table 5-46
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Current Residents - EPA Methodology

Depth Interval (feet)	Estimated Noncancer Hazard Index							
	Current Adult Resident				Current Child Resident			
	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	0.0009	0.08	0.004	**0.08**	0.002	0.7	0.03	**0.7**
0-2.0	0.0009	0.08	0.005	**0.08**	0.002	0.7	0.03	**0.7**
0-4.0	0.001	0.08	0.005	**0.09**	0.002	0.8	0.03	**0.8**

Table 5-47
Summary of Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Current Residents - CalEPA Methodology

Depth Interval (feet bgs)	Estimated Noncancer Hazard Index							
	Current Adult Resident				Current Child Resident			
	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	0.0009	0.08	0.004	**0.08**	0.002	0.7	0.03	**0.7**
0-2.0	0.0009	0.08	0.005	**0.08**	0.002	0.7	0.03	**0.7**
0-4.0	0.001	0.08	0.005	**0.09**	0.002	0.8	0.03	**0.8**

bgs denotes below ground surface

Table 5-48
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Future Residents - EPA Methodology

	Estimated Noncancer Hazard Index							
	Future Adult Resident				Future Child Resident			
Depth Interval (feet)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	0.0009	0.08	0.004	**0.08**	0.002	0.7	0.03	**0.7**
0-2.0	0.0009	0.08	0.005	**0.08**	0.002	0.7	0.03	**0.7**
0-4.0	0.001	0.08	0.005	**0.09**	0.002	0.8	0.03	**0.8**
0-8.0	0.001	0.1	0.005	**0.1**	0.003	0.9	0.04	**1**

Table 5-49
Summary of Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Future Residents - CalEPA Methodology

	Estimated Noncancer Hazard Index							
	Future Adult Resident				Future Child Resident			
Depth Interval (feet bgs)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-0.5	0.0009	0.08	0.004	**0.08**	0.002	0.7	0.03	**0.7**
0-2.0	0.0009	0.08	0.005	**0.08**	0.002	0.7	0.03	**0.7**
0-4.0	0.0011	0.08	0.005	**0.09**	0.002	0.8	0.03	**0.8**
0-8.0	0.001	0.1	0.005	**0.1**	0.003	0.9	0.04	**1**

bgs denotes below ground surface

Table 5-50
Summary of Estimated Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Construction Workers - EPA Methodology

	Estimated Noncancer Hazard Index			
Depth Interval (feet)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-8.0	0.36	0.17	0.003	0.5

Table 5-51
Summary of Pathway-Specific Noncancer Hazard Indices for Inorganic Chemicals in Soil - Construction Workers - CalEPA Methodology

	Estimated Noncancer Hazard Index			
Depth Interval (feet bgs)	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
0-8.0	0.36	0.17	0.022	**0.5**

bgs denotes below ground surface

Table 5-52
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Current Residents - EPA Methodology (VLEACH)

Chemical	Maximum Concentration* (ug/m^3)	Estimated Cancer Risk		Estimated Noncancer Hazard Index	
		Current Resident (adult)	Current Resident (child)	Current Resident (adult)	Current Resident (child)
Acetone	180	NC	NC	$4x10^{-5}$	0.0001
2-Butanone	28	NC	NC	$2x10^{-6}$	$4x10^{-6}$
Benzene	13	$4.8x10^{-10}$	$1.1x10^{-9}$	0.0001	0.0003
Chlorobenzene	ND	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND	ND
Chloroform	35	$4.6x10^{-9}$	$1.1x10^{-8}$	0.008	0.02
1,1-Dichloroethane	ND	ND	ND	ND	ND
1,1-Dichloroethene	3.9	$9.6x10^{-10}$	$2.2x10^{-9}$	$7x10^{-6}$	$2x10^{-5}$
cis-1,2-Dichloroethene	4	NC	NC	$5x10^{-6}$	$1x10^{-5}$
Ethylbenzene	86	NC	NC	$4x10^{-6}$	$1x10^{-5}$
2-Hexanone	4.1	NC	NC	NA	NA
4-Methyl-2-Pentanone	12	NC	NC	$7x10^{-6}$	$2x10^{-5}$
Methyl tert-Butyl Ether	77	$1.7x10^{-10}$	$4.0x10^{-10}$	$1x10^{-6}$	$3x10^{-6}$
Naphthalene	54	NA	NA	0.0007	0.002
Styrene	2.9	NC	NC	$1x10^{-7}$	$3x10^{-7}$
Tetrachloroethene	22	$5.0x10^{-11}$	$1.2x10^{-10}$	$3x10^{-6}$	$6x10^{-6}$
Toluene	230	NC	NC	$3x10^{-5}$	$8x10^{-5}$
1,1,1-Trichloroethane	ND	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND	ND
Vinyl Acetate	26	NC	NC	$7x10^{-6}$	$2x10^{-5}$
Xylenes (total)	430	NC	NC	$3x10^{-6}$	$7x10^{-6}$
Total		**$6x10^{-9}$**	**$1x10^{-8}$**	**0.009**	**0.02**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-53
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Current Residents - CalEPA Methodology (Johnson and Ettinger)

Chemical	Maximum Concentration* (ug/m^3)	Cancer Risk Current Resident (adult)	Noncancer Hazard Index Current Resident (adult)
Acetone	180	NC	5.5E-06
2-Butanone	28	NC	2.9E-07
Benzene	13	1.6E-09	2.2E-06
Chlorobenzene	ND	ND	ND
Chloroethane	ND	ND	ND
Chloroform	35	8.2E-10	1.2E-06
1,1-Dichloroethane	ND	ND	ND
1,1-Dichloroethene	3.9	NA	5.6E-07
cis-1,2-Dichloroethene	4	NC	1.1E-06
Ethylbenzene	86	NC	4.2E-07
2-Hexanone	4.1	NA	NA
4-Methyl-2-Pentanone	12	NC	1.5E-06
Methyl tert-Butyl Ether	77	8.8E-11	9.9E-08
Naphthalene	54	NA	5.7E-05
Styrene	2.9	NA	3.2E-08
Tetrachloroethene	22	5.5E-10	6.2E-06
Toluene	230	NC	7.7E-06
1,1,1-Trichloroethane	ND	ND	ND
Trichloroethene	ND	ND	ND
Vinyl Acetate	26	NA	1.3E-06
Xylenes (total)	430	NC	6.2E-06
Total		**3E-09**	**0.00009**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-54
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Future Residents - EPA Methodology (VLEACH)

Chemical	Maximum Concentration* (ug/m^3)	Estimated Cancer Risk	Estimated Noncancer Hazard Index	
		Future Resident (age-adjusted)	Future Resident (adult)	Future Resident (child)
Acetone	180	NC	$4x10^{-5}$	0.0001
2-Butanone	28	NC	$2x10^{-6}$	$4x10^{-6}$
Benzene	13	$3.1x10^{-9}$	0.0001	0.0003
Chlorobenzene	ND	ND	ND	ND
Chloroethane	ND	ND	ND	ND
Chloroform	35	$2.9x10^{-8}$	0.008	0.02
1,1-Dichloroethane	ND	ND	ND	ND
1,1-Dichloroethene	3.9	$6.1x10^{-9}$	$7x10^{-6}$	$2x10^{-5}$
cis-1,2-Dichloroethene	4	NC	$5x10^{-6}$	$1x10^{-5}$
Ethylbenzene	86	NC	$4x10^{-6}$	$1x10^{-5}$
2-Hexanone	4.1	NC	NA	NA
4-Methyl-2-Pentanone	12	NC	$7x10^{-6}$	$2x10^{-5}$
Methyl tert-Butyl Ether	77	$1.1x10^{-9}$	$1x10^{-6}$	$3x10^{-6}$
Naphthalene	54	NA	0.0007	0.002
Styrene	2.9	NC	$1x10^{-7}$	$3x10^{-7}$
Tetrachloroethene	22	$3.1x10^{-10}$	$3x10^{-6}$	$6x10^{-6}$
Toluene	230	NC	$3x10^{-5}$	$8x10^{-5}$
1,1,1-Trichloroethane	ND	ND	ND	ND
Trichloroethene	ND	ND	ND	ND
Vinyl Acetate	26	NC	$7x10^{-6}$	$2x10^{-5}$
Xylenes (total)	430	NC	$3x10^{-6}$	$7x10^{-6}$
Total		**$4x10^{-8}$**	**0.009**	**0.02**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-55
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Future Residents - CalEPA Methodology (Johnson and Ettinger)

Chemical	Maximum* Concentration (ug/m^3)	Estimated Cancer Risk Future Resident (adult)	Estimated Noncancer Hazard Index Future Resident (adult)
Acetone	180	NC	$2.8x10^{-5}$
2-Butanone	28	NC	$1.5x10^{-6}$
Benzene	13	$8.2x10^{-9}$	$1.1x10^{-5}$
Chlorobenzene	ND	ND	ND
Chloroethane	ND	ND	ND
Chloroform	35	$4.1x10^{-9}$	$6.0x10^{-6}$
1,1-Dichloroethane	ND	ND	ND
1,1-Dichloroethene	3.9	NA	$2.8x10^{-6}$
cis-1,2-Dichloroethene	4	NC	$5.6x10^{-6}$
Ethylbenzene	86	NC	$2.1x10^{-6}$
2-Hexanone	4.1	NA	NA
4-Methyl-2-Pentanone	12	NC	$7.4x10^{-6}$
Methyl tert-Butyl Ether	77	$4.4x10^{-10}$	$5.0x10^{-7}$
Naphthalene	54	NA	$2.9x10^{-4}$
Styrene	2.9	NA	$1.6x10^{-7}$
Tetrachloroethene	22	$2.7x10^{-9}$	$3.1x10^{-5}$
Toluene	230	NC	$3.9x10^{-5}$
1,1,1-Trichloroethane	ND	ND	ND
Trichloroethene	ND	ND	ND
Vinyl Acetate	26	NA	$6.6x10^{-6}$
Xylenes (total)	430	NC	$3.1x10^{-5}$
Total		**$2x10^{-8}$**	**0.0005**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-56
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Off Site Properties - Future Residents - EPA Methodology (VLEACH)

Chemical	Maximum Concentration* (ug/m^3)	Estimated Cancer Risk	Estimated Noncancer Hazard Index	
		Future Resident (age-adjusted)	Future Resident (adult)	Future Resident (child)
Acetone	310	NC	$7x10^{-5}$	0.0002
2-Butanone	240	NC	$1x10^{-5}$	$3x10^{-5}$
Benzene	20	$4.7x10^{-9}$	0.0002	0.0004
Chlorobenzene	28	NC	$2x10^{-5}$	$5x10^{-5}$
Chloroethane	5.2	$1.5x10^{-10}$	$3x10^{-8}$	$8x10^{-8}$
Chloroform	92	$7.7x10^{-8}$	0.02	0.05
1,1-Dichloroethane	38	NC	$4x10^{-6}$	$9x10^{-6}$
1,1-Dichloroethene	ND	ND	ND	ND
cis-1,2-Dichloroethene	19	NC	$3x10^{-5}$	$6x10^{-5}$
Ethylbenzene	390	NC	$2x10^{-5}$	$4x10^{-5}$
2-Hexanone	29	NC	NA	NA
4-Methyl-2-Pentanone	78	NC	$5x10^{-5}$	0.0001
Methyl tert-Butyl Ether	170	$2.4x10^{-9}$	$3x10^{-6}$	$7x10^{-6}$
Naphthalene	180	NA	0.002	0.006
Styrene	7.2	NC	$3x10^{-7}$	$8x10^{-7}$
Tetrachloroethene	86	$1.2x10^{-9}$	$1x10^{-5}$	$2x10^{-5}$
Toluene	300	NC	$4x10^{-5}$	0.0001
1,1,1-Trichloroethane	27	NC	$1x10^{-6}$	$3x10^{-6}$
Trichloroethene	130	$6.1x10^{-9}$	0.0003	0.0006
Vinyl Acetate	76	NC	$2x10^{-5}$	$5x10^{-5}$
Xylenes (total)	2810	NC	$2x10^{-5}$	$5x10^{-5}$
Total		**$9x10^{-8}$**	**0.02**	**0.06**

** Maximum concentration detected for each chemical in samples from outside Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected in off-site properties

Table 5-57

Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Off Site Properties - Future Residents - CalEPA Methodology (Johnson and Ettinger)

Chemical	Maximum* Concentration (ug/m^3)	Cancer Risk Future Resident (adult)	Noncancer Hazard Index Future Resident (adult)
Acetone	310	NC	$4.8x10^{-5}$
2-Butanone	240	NC	$1.3x10^{-5}$
Benzene	20	$1.3x10^{-8}$	$1.7x10^{-5}$
Chlorobenzene	28	NC	$1.4x10^{-6}$
Chloroethane	5.2	$9.5x10^{-11}$	$8.9x10^{-9}$
Chloroform	92	$1.1x10^{-8}$	$1.6x10^{-5}$
1,1-Dichloroethane	38	$1.3x10^{-9}$	$3.7x10^{-6}$
1,1-Dichloroethene	ND	ND	ND
cis-1,2-Dichloroethene	19	NC	$2.7x10^{-5}$
Ethylbenzene	390	NC	$9.6x10^{-6}$
2-Hexanone	29	NA	NA
4-Methyl-2-Pentanone	78	NC	$4.8x10^{-5}$
Methyl tert-Butyl Ether	170	$9.8x10^{-10}$	$1.1x10^{-6}$
Naphthalene	180	NA	$9.6x10^{-4}$
Styrene	7.2	NA	$3.9x10^{-7}$
Tetrachloroethene	86	$1.1x10^{-8}$	$1.2x10^{-4}$
Toluene	300	NC	$5.0x10^{-5}$
1,1,1-Trichloroethane	27	NC	$1.3x10^{-6}$
Trichloroethene	130	$5.5x10^{-9}$	$1.1x10^{-5}$
Vinyl Acetate	76	NA	$1.9x10^{-5}$
Xylenes (total)	2810	NC	$2.0x10^{-4}$
Total		**$4x10^{-8}$**	**0.002**

** Maximum concentration detected for each chemical in samples from outside Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected in off-site properties

Table 5-58
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum Concentration* (ug/m^3)	Estimated Cancer Risk	Estimated Noncancer Hazard Index
Acetone	180	NC	$3x10^{-6}$
2-Butanone	28	NC	$1x10^{-7}$
Benzene	13	$6.2x10^{-12}$	$1x10^{-5}$
Chlorobenzene	ND	ND	ND
Chloroethane	ND	ND	ND
Chloroform	35	$5.9x10^{-11}$	0.0006
1,1-Dichloroethane	ND	ND	ND
1,1-Dichloroethene	3.9	$1.2x10^{-11}$	$6x10^{-7}$
cis-1,2-Dichloroethene	4	NC	$4x10^{-7}$
Ethylbenzene	86	NC	$3x10^{-7}$
2-Hexanone	4.1	NC	NA
4-Methyl-2-Pentanone	12	NC	$6x10^{-7}$
Methyl tert-Butyl Ether	77	$2.2x10^{-12}$	$1x10^{-7}$
Naphthalene	54	NA	$5x10^{-5}$
Styrene	2.9	NC	$1x10^{-8}$
Tetrachloroethene	22	$6.4x10^{-13}$	$2x10^{-7}$
Toluene	230	NC	$3x10^{-6}$
1,1,1-Trichloroethane	ND	ND	ND
Trichloroethene	ND	ND	ND
Vinyl Acetate	26	NC	$4x10^{-8}$
Xylenes (total)	430	NC	$3x10^{-7}$
Total		**$8x10^{-11}$**	**0.0007**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-59
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Parcel 181 - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/m^3)	Cancer Risk	Noncancer Hazard Index
Acetone	180	NC	$3x10^{-6}$
2-Butanone	28	NC	$1x10^{-7}$
Benzene	13	$2.3x10^{-11}$	$9x10^{-7}$
Chlorobenzene	ND	ND	ND
Chloroethane	ND	ND	ND
Chloroform	35	$1.4x10^{-11}$	$6x10^{-7}$
1,1-Dichloroethane	ND	ND	ND
1,1-Dichloroethene	3.9	NA	$2x10^{-7}$
cis-1,2-Dichloroethene	4	NC	$4x10^{-7}$
Ethylbenzene	86	NC	$2x10^{-7}$
2-Hexanone	4.1	NA	NA
4-Methyl-2-Pentanone	12	NC	$6x10^{-7}$
Methyl tert-Butyl Ether	77	$2.2x10^{-12}$	$4x10^{-8}$
Naphthalene	54	NA	$2x10^{-5}$
Styrene	2.9	NA	$1x10^{-8}$
Tetrachloroethene	22	$6.7x10^{-12}$	$2x10^{-6}$
Toluene	230	NC	$3x10^{-6}$
1,1,1-Trichloroethane	ND	ND	ND
Trichloroethene	ND	ND	ND
Vinyl Acetate	26	NA	$4x10^{-8}$
Xylenes (total)	430	NC	$3x10^{-6}$
Total		**$5x10^{-11}$**	**0.00003**

** Maximum concentration detected for each chemical in samples from Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-60
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Off Site Properties - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum Concentration* (ug/m^3)	Estimated Cancer Risk	Index
Acetone	310	NC	$5x10^{-6}$
2-Butanone	240	NC	$1x10^{-6}$
Benzene	20	$9.6x10^{-12}$	$1x10^{-5}$
Chlorobenzene	28	NC	$2x10^{-6}$
Chloroethane	5.2	$3.0x10^{-13}$	$3x10^{-9}$
Chloroform	92	$1.6x10^{-10}$	0.002
1,1-Dichloroethane	38	NC	$3x10^{-7}$
1,1-Dichloroethene	ND	ND	ND
cis-1,2-Dichloroethene	19	NC	$2x10^{-6}$
Ethylbenzene	390	NC	$1x10^{-6}$
2-Hexanone	29	NC	NA
4-Methyl-2-Pentanone	78	NC	$4x10^{-6}$
Methyl tert-Butyl Ether	170	$4.9x10^{-12}$	$2x10^{-7}$
Naphthalene	180	NA	0.0002
Styrene	7.2	NC	$2x10^{-8}$
Tetrachloroethene	86	$2.5x10^{-12}$	$8x10^{-7}$
Toluene	300	NC	$3x10^{-6}$
1,1,1-Trichloroethane	27	NC	$1x10^{-7}$
Trichloroethene	130	$1.2x10^{-11}$	$2x10^{-5}$
Vinyl Acetate	76	NC	$1x10^{-7}$
Xylenes (total)	2810	NC	$2x10^{-6}$
Total		**$2x10^{-10}$**	**0.002**

** Maximum concentration detected for each chemical in samples outside Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected in off-site properties

Table 5-61
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Soil Gas - Off Site Properties - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/m^3)	Cancer Risk	Noncancer Hazard Index
Acetone	310	NC	$5x10^{-6}$
2-Butanone	240	NC	$1x10^{-6}$
Benzene	20	$3.6x10^{-11}$	$1x10^{-6}$
Chlorobenzene	28	NC	$1x10^{-7}$
Chloroethane	5.2	$3.0x10^{-13}$	$9x10^{-10}$
Chloroform	92	$3.7x10^{-11}$	$2x10^{-6}$
1,1-Dichloroethane	38	$3.2x10^{-12}$	$3x10^{-7}$
1,1-Dichloroethene	ND	ND	ND
cis-1,2-Dichloroethene	19	NC	$2x10^{-6}$
Ethylbenzene	390	NC	$7x10^{-7}$
2-Hexanone	29	NA	NA
4-Methyl-2-Pentanone	78	NC	$4x10^{-6}$
Methyl tert-Butyl Ether	170	$4.9x10^{-12}$	$8x10^{-8}$
Naphthalene	180	NA	$6x10^{-5}$
Styrene	7.2	NA	$3x10^{-8}$
Tetrachloroethene	86	$2.6x10^{-11}$	$9x10^{-6}$
Toluene	300	NC	$4x10^{-6}$
1,1,1-Trichloroethane	27	NC	$1x10^{-7}$
Trichloroethene	130	$2.1x10^{-11}$	$8x10^{-7}$
Vinyl Acetate	76	NA	$1x10^{-7}$
Xylenes (total)	2810	NC	$2x10^{-5}$
Total		**$1x10^{-10}$**	**0.0001**

** Maximum concentration detected for each chemical in samples outside Parcel 181 used to calculate risks and hazard indices*

ug/m^3 denotes micrograms per cubic meter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected in off-site properties

Table 5-62
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Parcel 181 Shallow Hydropunch - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Estimated Cancer Risk	Estimated Noncancer Hazard Index
Acenaphthene	59	NC	$4x10^{-7}$
Anthracene	2	NC	$3x10^{-10}$
Benzene	4.2	$1.9x10^{-10}$	0.0003
Bromodichloromethane	0.22	$2.2x10^{-12}$	$1x10^{-7}$
Dibromochloromethane	0.23	$1.0x10^{-12}$	$4x10^{-8}$
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	0.4	NC	$3x10^{-6}$
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	1	NC	$5x10^{-7}$
Fluorene	0.9	NC	$1x10^{-9}$
Isopropyl Benzene	0.28	NC	$5x10^{-5}$
4-Isopropyltoluene	0.4	NA	NA
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	1.1	$3.2x10^{-13}$	$1x10^{-8}$
Naphthalene	49	NA	0.0004
Phenanthrene	4.1	NC	$7x10^{-8}$
Pyrene	38	NC	$9x10^{-8}$
Toluene	1.1	NC	$1x10^{-6}$
1,2,4-Trimethylbenzene	0.4	NC	$2x10^{-5}$
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	3.3	NC	$2x10^{-7}$
Total		**$2x10^{-10}$**	**0.0008**

** Maximum concentration detected for each chemical in hydropunch samples from Parcel 181 used to calculate risks and hazard indices*

ug/L denotes micrograms per liter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-63
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Parcel 181 Shallow Hydropunch - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Cancer Risk	Noncancer Hazard Index
Acenaphthene	59	NA	$4x10^{-7}$
Anthracene	2	NC	$3x10^{-10}$
Benzene	4.2	$7.1x10^{-10}$	$3x10^{-5}$
Bromodichloromethane	0.22	$4.7x10^{-12}$	$1x10^{-7}$
Dibromochloromethane	0.23	$1.0x10^{-12}$	$4x10^{-8}$
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	0.4	NC	$3x10^{-6}$
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	1	NC	$2x10^{-7}$
Fluorene	0.9	NC	$1x10^{-9}$
Isopropyl Benzene	0.28	NC	$5x10^{-5}$
4-Isopropyltoluene	0.4	NA	NA
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	1.1	$3.2x10^{-13}$	$5x10^{-9}$
Naphthalene	49	NA	$1x10^{-4}$
Phenanthrene	4.1	NC	$7x10^{-8}$
Pyrene	38	NC	$9x10^{-8}$
Toluene	1.1	NC	$2x10^{-6}$
1,2,4-Trimethylbenzene	0.4	NA	$2x10^{-5}$
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	3.3	NC	$2x10^{-6}$
Total		**$7x10^{-10}$**	**0.0002**

** Maximum concentration detected for each chemical in hydropunch samples from Parcel 181 used to calculate risks and hazard indices*
ug/L denotes micrograms per liter
NA denotes Not available
NC denotes Not known to be a carcinogen
ND denotes Not detected within Parcel 181

Table 5-64
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Off Site Properties Shallow Hydropunch - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Estimated Cancer Risk	Estimated Noncancer Hazard Index
Acenaphthene	ND	ND	ND
Anthracene	3.1	NC	$4x10^{-10}$
Benzene	41	$1.9x10^{-9}$	0.003
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	1.2	NC	$9x10^{-6}$
trans-1,2-Dichloroethene	0.25	NC	$2x10^{-6}$
Ethylbenzene	24	NC	$1x10^{-5}$
Fluorene	0.5	NC	$8x10^{-10}$
Isopropyl Benzene	ND	ND	ND
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	7	$8.6x10^{-12}$	$4x10^{-7}$
Methyl tert-Butyl Ether	1.2	$3.4x10^{-13}$	$2x10^{-8}$
Naphthalene	270	NA	0.002
Phenanthrene	4	NC	$7x10^{-8}$
Pyrene	14	NC	$3x10^{-8}$
Toluene	3	NC	$4x10^{-6}$
1,2,4-Trimethylbenzene	2	NC	0.0001
Vinyl Chloride	0.79	$2.4x10^{-10}$	$2x10^{-5}$
Xylenes (Total)	23	NC	$1x10^{-6}$
Total		**$2x10^{-9}$**	**0.005**

** Maximum concentration detected for each chemical in hydropunch samples from outside Parcel 181 used to calculate risks and hazard indices*
ug/L denotes micrograms per liter
NA denotes Not available
NC denotes Not known to be a carcinogen
ND denotes Not detected in off-site properties

Table 5-65
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Off Site Properties Shallow Hydropunch - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Cancer Risk	Noncancer Hazard Index
Acenaphthene	ND	ND	ND
Anthracene	3.1	NC	$4x10^{-10}$
Benzene	41	$6.9x10^{-9}$	$3x10^{-4}$
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	1.2	NC	$9x10^{-6}$
trans-1,2-Dichloroethene	0.25	NA	$2x10^{-6}$
Ethylbenzene	24	NC	$6x10^{-6}$
Fluorene	0.5	NC	$8x10^{-10}$
Isopropyl Benzene	ND	ND	ND
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	7	$1.9x10^{-11}$	$3x10^{-6}$
Methyl tert-Butyl Ether	1.2	$3.4x10^{-13}$	$6x10^{-9}$
Naphthalene	270	NA	$7x10^{-4}$
Phenanthrene	4	NC	$7x10^{-8}$
Pyrene	14	NC	$3x10^{-8}$
Toluene	3	NC	$5x10^{-6}$
1,2,4-Trimethylbenzene	2	NA	$1x10^{-4}$
Vinyl Chloride	0.79	$2.1x10^{-9}$	$2x10^{-5}$
Xylenes (Total)	23	NC	$1x10^{-5}$
Total		**$9x10^{-9}$**	**0.001**

** Maximum concentration detected for each chemical in hydropunch samples from outside Parcel 181 used to calculate risks and hazard indices*

ug/L denotes micrograms per liter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected in off-site properties

Table 5-66
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Parcel 181 Shallow Monitoring Wells - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Estimated Cancer Risk	Estimated Noncancer Hazard Index
Acenaphthene	ND	ND	ND
Anthracene	2	NC	$3x10^{-10}$
Benzene	ND	ND	ND
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	2.3	NC	$1x10^{-5}$
Fluorene	3	NC	$5x10^{-9}$
Isopropyl Benzene	0.3	NC	$6x10^{-5}$
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	19	$5.4x10^{-12}$	$2x10^{-7}$
Naphthalene	ND	ND	ND
Phenanthrene	7	NC	$1x10^{-7}$
Pyrene	8.7	NC	$2x10^{-8}$
Toluene	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	ND	ND	ND
Total		**$5x10^{-12}$**	**0.00006**

** Maximum concentration detected for each chemical in monitoring well samples from Parcel 181 used to calculate risks and hazard indices.*

ug/L denotes micrograms per liter

NA denotes Not available

NC denotes Not known to be a carcinogen

ND denotes Not detected within Parcel 181

Table 5-67
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Parcel 181 Shallow Monitoring Wells - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Cancer Risk	Noncancer Hazard Index
Acenaphthene	ND	ND	ND
Anthracene	2	NC	$3x10^{-10}$
Benzene	ND	ND	ND
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	ND	ND	ND
cis-1,2-Dichloroethene	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	2.3	NC	$6x10^{-7}$
Fluorene	3	NC	$5x10^{-9}$
Isopropyl Benzene	0.3	NC	$6x10^{-5}$
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	19	$5.5x10^{-12}$	$9x10^{-8}$
Naphthalene	ND	ND	ND
Phenanthrene	7	NC	$1x10^{-7}$
Pyrene	8.7	NC	$2x10^{-8}$
Toluene	ND	ND	ND
1,2,4-Trimethylbenzene	ND	ND	ND
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	ND	ND	ND
Total		**$5x10^{-12}$**	**0.00006**

** Maximum concentration detected for each chemical in monitoring well samples from Parcel 181 used to calculate risks and hazard indices.*
ug/L denotes micrograms per liter
NA denotes Not available
NC denotes Not known to be a carcinogen
ND denotes Not detected within Parcel 181

Table 5-68
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Off Site Properties Shallow Monitoring Wells - Construction Workers - EPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Estimated Cancer Risk	Estimated Noncancer Hazard Index
Acenaphthene	66	NC	$4x10^{-7}$
Anthracene	0.8	NC	$1x10^{-10}$
Benzene	673	$3.1x10^{-8}$	0.05
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	23	$7.3x10^{-10}$	0.0004
cis-1,2-Dichloroethene	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	90	NC	$4x10^{-5}$
Fluorene	3	NC	$5x10^{-9}$
Isopropyl Benzene	2	NC	0.0004
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	3	$8.6x10^{-13}$	$4x10^{-8}$
Naphthalene	2400	NA	0.02
Phenanthrene	21	NC	$4x10^{-7}$
Pyrene	5.7	NC	$1x10^{-8}$
Toluene	140	NC	0.0002
1,2,4-Trimethylbenzene	11	NC	0.0007
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	120	NC	$8x10^{-6}$
Total		**$3x10^{-8}$**	**0.07**

** Maximum concentration detected for each chemical in monitoring well samples from outside Parcel 181 used to calculate risks and hazard indices.*
ug/L denotes micrograms per liter
NA denotes Not available
NC denotes Not known to be a carcinogen
ND denotes Not detected in off-site properties

Table 5-69
Maximum Estimated Cancer Risks and Noncancer Hazard Indices for Volatile Organic Compounds in Shallow Groundwater - Off Site Properties Shallow Monitoring Wells - Construction Workers - CalEPA Methodology (VLEACH)

Chemical	Maximum* Concentration (ug/L)	Cancer Risk	Noncancer Hazard Index
Acenaphthene	66	NA	$4x10^{-7}$
Anthracene	0.8	NC	$1x10^{-10}$
Benzene	673	$1.1x10^{-7}$	$5x10^{-3}$
Bromodichloromethane	ND	ND	ND
Dibromochloromethane	ND	ND	ND
1,2-Dichloroethane	23	$5.8x10^{-10}$	$4x10^{-4}$
cis-1,2-Dichloroethene	ND	ND	ND
trans-1,2-Dichloroethene	ND	ND	ND
Ethylbenzene	90	NC	$2x10^{-5}$
Fluorene	3	NC	$5x10^{-9}$
Isopropyl Benzene	2	NC	$4x10^{-4}$
4-Isopropyltoluene	ND	ND	ND
Methylene Chloride	ND	ND	ND
Methyl tert-Butyl Ether	3	$8.6x10^{-13}$	$1x10^{-8}$
Naphthalene	2400	NA	$6x10^{-3}$
Phenanthrene	21	NC	$4x10^{-7}$
Pyrene	5.7	NC	$1x10^{-8}$
Toluene	140	NC	$2x10^{-4}$
1,2,4-Trimethylbenzene	11	NA	$7x10^{-4}$
Vinyl Chloride	ND	ND	ND
Xylenes (Total)	120	NC	$8x10^{-5}$
Total		**$1x10^{-7}$**	**0.01**

** Maximum concentration detected for each chemical in monitoring well samples from outside Parcel 181 used to calculate risks and hazard indices.*
ug/L denotes micrograms per liter
NA denotes Not available
NC denotes Not known to be a carcinogen
ND denotes Not detected in off-site properties

Table 5-70
Cumulative Estimated Risks and Noncancer Hazard Indices - Parcel 181 - Current Residents - EPA Methodology

Area	Depth Interval (feet)	Estimted Cancer Risk (child)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
1	0-0.5	$1x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.003	0.7	0.02	0.7
1	0-2.0	$5x10^{-6}$	$7x10^{-6}$	$1x10^{-8}$	$1x10^{-5}$	$5x10^{-6}$	0.001	0.7	0.02	0.7
1	0-4.0	$5x10^{-6}$	$8x10^{-6}$	$1x10^{-8}$	$1x10^{-5}$	$5x10^{-6}$	0.001	0.8	0.02	0.8
2	0-0.5	$3x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.006	0.7	0.02	0.7
2	0-2.0	$2x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.005	0.7	0.02	0.7
2	0-4.0	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$3x10^{-5}$	0.01	0.8	0.02	0.8
3	0-0.5	$1x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.003	0.7	0.02	0.7
3	0-2.0	$9x10^{-6}$	$7x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$9x10^{-6}$	0.002	0.7	0.02	0.7
3	0-4.0	$8x10^{-6}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$8x10^{-6}$	0.002	0.8	0.02	0.8
4	0-0.5	$3x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.009	0.7	0.02	0.7
4	0-2.0	$3x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.002	0.7	0.02	0.7
4	0-4.0	$4x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$5x10^{-5}$	$4x10^{-5}$	0.009	0.8	0.02	0.8
5	0-0.5	$3x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.009	0.7	0.02	0.7
5	0-2.0	$4x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$5x10^{-5}$	$4x10^{-5}$	0.001	0.7	0.02	0.7
5	0-4.0	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.001	0.8	0.02	0.8
6	0-0.5	$1x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.003	0.7	0.02	0.7
6	0-2.0	$2x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.005	0.7	0.02	0.7
6	0-4.0	$3x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.008	0.8	0.02	0.8
7	0-0.5	$1x10^{-4}$	$7x10^{-6}$	$1x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.04	0.7	0.02	0.7
7	0-2.0	$8x10^{-5}$	$7x10^{-6}$	$1x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.02	0.7	0.02	0.7
7	0-4.0	$7x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$8x10^{-5}$	$7x10^{-5}$	0.02	0.8	0.02	0.8

PAH denotes polynuclear aromatic hydrocarbon

Decision areas 1 through 7 defined on the basis of similar soil benzo(a)pyrene-equivalent concentrations from 0 to 4 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

Table 5-71
Cumulative Estimated Risks and Noncancer Hazard Indices - Parcel 181 - Current Residents - CalEPA Methodology

Area	Depth Interval (feet)	Estimted Cancer Risk (child)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
1	0-0.5	$2x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.001	0.7
1	0-2.0	$9x10^{-6}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$9x10^{-6}$	0.001	0.7	0.001	0.7
1	0-4.0	$9x10^{-6}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$9x10^{-6}$	0.001	0.8	0.001	0.8
2	0-0.5	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.006	0.7	0.001	0.7
2	0-2.0	$4x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$4x10^{-5}$	0.006	0.7	0.001	0.7
2	0-4.0	$8x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.01	0.8	0.001	0.8
3	0-0.5	$2x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.001	0.7
3	0-2.0	$1x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.002	0.7	0.001	0.7
3	0-4.0	$1x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.002	0.8	0.001	0.8
4	0-0.5	$6x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$6x10^{-5}$	0.009	0.7	0.001	0.7
4	0-2.0	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.002	0.7	0.001	0.7
4	0-4.0	$7x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$8x10^{-5}$	$7x10^{-5}$	0.009	0.8	0.001	0.8
5	0-0.5	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.009	0.7	0.001	0.7
5	0-2.0	$6x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$7x10^{-5}$	$6x10^{-5}$	0.001	0.7	0.001	0.7
5	0-4.0	$8x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$8x10^{-5}$	$8x10^{-5}$	0.001	0.8	0.001	0.8
6	0-0.5	$2x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.001	0.7
6	0-2.0	$3x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.005	0.7	0.001	0.7
6	0-4.0	$5x10^{-5}$	$8x10^{-6}$	$1x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.008	0.8	0.001	0.8
7	0-0.5	$2x10^{-4}$	$8x10^{-6}$	$1x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.04	0.7	0.001	0.7
7	0-2.0	$1x10^{-4}$	$8x10^{-6}$	$1x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.02	0.7	0.001	0.7
7	0-4.0	$1x10^{-4}$	$8x10^{-6}$	$1x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.02	0.8	0.001	0.8

PAH denotes polynuclear aromatic hydrocarbon

Decision areas 1 through 7 defined on the basis of similar soil benzo(a)pyrene-equivalent concentrations from 0 to 4 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

Table 5-72 (Page 1 of 2)
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk (age-adjusted)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
1	0-0.5	$2x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.02	0.7
1	0-2.0	$8x10^{-6}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-5}$	$8x10^{-6}$	0.001	0.7	0.02	0.7
1	0-4.0	$8x10^{-6}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-5}$	$8x10^{-6}$	0.001	0.8	0.02	0.8
1	0-8.0	$1x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.002	1	0.02	1
2	0-0.5	$5x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.006	0.7	0.02	0.7
2	0-2.0	$3x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.005	0.7	0.02	0.7
2	0-4.0	$7x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$8x10^{-5}$	$7x10^{-5}$	0.01	0.8	0.02	0.8
2	0-8.0	$2x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.03	1	0.02	1
3	0-0.5	$2x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.02	0.7
3	0-2.0	$1x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.002	0.7	0.02	0.7
3	0-4.0	$1x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.002	0.8	0.02	0.8
3	0-8.0	$2x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.02	1	0.02	1
4	0-0.5	$5x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.009	0.7	0.02	0.7
4	0-2.0	$5x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.002	0.7	0.02	0.7
4	0-4.0	$6x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$7x10^{-5}$	$6x10^{-5}$	0.009	0.8	0.02	0.8
4	0-8.0	$8x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.02	1	0.02	1
5	0-0.5	$5x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.009	0.7	0.02	0.7
5	0-2.0	$6x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$7x10^{-5}$	$6x10^{-5}$	0.001	0.7	0.02	0.7
5	0-4.0	$7x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$8x10^{-5}$	$7x10^{-5}$	0.001	0.8	0.02	0.8
5	0-8.0	$4x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$5x10^{-5}$	$4x10^{-5}$	0.009	1	0.02	1

Table 5-72 (Page 2 of 2)
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk (age-adjusted)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
6	0-0.5	$2x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.003	0.7	0.02	0.7
6	0-2.0	$3x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.005	0.7	0.02	0.7
6	0-4.0	$5x10^{-5}$	$1x10^{-5}$	$4x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.008	0.8	0.02	0.8
6	0-8.0	$2x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$3x10^{-4}$	$2x10^{-4}$	0.04	1	0.02	1
7	0-0.5	$2x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.04	0.7	0.02	0.7
7	0-2.0	$1x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.02	0.7	0.02	0.7
7	0-4.0	$1x10^{-4}$	$1x10^{-5}$	$4x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.02	0.8	0.02	0.8
7	0-8.0	$1x10^{-3}$	$1x10^{-5}$	$4x10^{-8}$	$1x10^{-3}$	$1x10^{-3}$	0.7	1	0.02	2

PAH denotes polynuclear aromatic hydrocarbon

Decision areas 1 through 7 defined on the basis of similar soil benzo(a)oyrene-equivalent concentrations from 0 to 4 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

Table 5-73 (Page 1 of 2)
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Future Residents - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk (age-adjusted)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
1	0-0.5	$3x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.003	0.7	0.001	0.7
1	0-2.0	$1x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.001	0.7	0.001	0.7
1	0-4.0	$1x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$2x10^{-5}$	$1x10^{-5}$	0.001	0.8	0.001	0.8
1	0-8.0	$2x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.002	1	0.001	1
2	0-0.5	$8x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.006	0.7	0.001	0.7
2	0-2.0	$5x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.006	0.7	0.001	0.7
2	0-4.0	$1x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.01	0.8	0.001	0.8
2	0-8.0	$3x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-4}$	$3x10^{-4}$	0.03	1	0.001	1
3	0-0.5	$3x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$4x10^{-5}$	$3x10^{-5}$	0.003	0.7	0.001	0.7
3	0-2.0	$2x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.002	0.7	0.001	0.7
3	0-4.0	$2x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-5}$	$2x10^{-5}$	0.002	0.8	0.001	0.8
3	0-8.0	$3x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-4}$	$3x10^{-4}$	0.02	1	0.001	1
4	0-0.5	$8x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.009	0.7	0.001	0.7
4	0-2.0	$8x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.002	0.7	0.001	0.7
4	0-4.0	$1x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.009	0.8	0.001	0.8
4	0-8.0	$1x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.02	1	0.001	1
5	0-0.5	$8x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.009	0.7	0.001	0.7
5	0-2.0	$9x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$1x10^{-4}$	$9x10^{-5}$	0.001	0.7	0.001	0.7
5	0-4.0	$1x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$1x10^{-4}$	$1x10^{-4}$	0.001	0.8	0.001	0.8
5	0-8.0	$7x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$8x10^{-5}$	$7x10^{-5}$	0.009	1	0.001	1

Table 5-73 (Page 2 of 2)
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Future Residents - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk (age-adjusted)					Estimated Noncancer Hazard Index (child)			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
6	0-0.5	$4x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$5x10^{-5}$	$4x10^{-5}$	0.003	0.7	0.001	0.7
6	0-2.0	$5x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$6x10^{-5}$	$5x10^{-5}$	0.005	0.7	0.001	0.7
6	0-4.0	$8x10^{-5}$	$1x10^{-5}$	$3x10^{-8}$	$9x10^{-5}$	$8x10^{-5}$	0.008	0.8	0.001	0.8
6	0-8.0	$4x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$4x10^{-4}$	$4x10^{-4}$	0.04	1	0.001	1
7	0-0.5	$3x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$3x10^{-4}$	$3x10^{-4}$	0.04	0.7	0.001	0.7
7	0-2.0	$2x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.02	0.7	0.001	0.7
7	0-4.0	$2x10^{-4}$	$1x10^{-5}$	$3x10^{-8}$	$2x10^{-4}$	$2x10^{-4}$	0.02	0.8	0.001	0.8
7	0-8.0	$2x10^{-3}$	$1x10^{-5}$	$3x10^{-8}$	$2x10^{-3}$	$2x10^{-3}$	0.7	1	0.001	2

PAH denotes polynuclear aromatic hydrocarbon

Decision areas 1 through 7 defined on the basis of similar soil benzo(a)oyrene-equivalent concentrations from 0 to 4 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

Table 5-74
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Construction Workers - EPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk					Estimated Hazard Index			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
All of Parcel 181	**0-8.0**	$3x10^{-6}$	$7x10^{-7}$	$2x10^{-10}$	$4x10^{-6}$	$3x10^{-6}$	0.009	0.5	0.0008	0.5
Northern Parcel	**0-8.0**	$6x10^{-6}$	$7x10^{-7}$	$2x10^{-10}$	$7x10^{-6}$	$6x10^{-6}$	0.03	0.5	0.0008	0.5
Southern Parcel	**0-8.0**	$8x10^{-7}$	$7x10^{-7}$	$2x10^{-10}$	$2x10^{-6}$	$8x10^{-7}$	0.001	0.5	0.0008	0.5

PAH denotes polynuclear aromatic hydrocarbon

Northern and southern areas defined on the basis of similar soil benzo(a)pyrene-equivalent concentrations from 4 to 8 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181, using the greater of soil gas, hydropunch groundwater, or monitoring well groundwater samples; the hydropunch samples yielded both the maximum cancer risk and the maximum hazard index.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

Table 5-75
Cumulative Cancer Risks and Noncancer Hazard Indices - Parcel 181 - Construction Workers - CalEPA Methodology

Area	Depth Interval (feet)	Estimated Cancer Risk					Estimated Hazard Index			
		PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Cancer Risk	Incremental Cancer Risk	PAHs in Soil	Metals in Soil	VOCs in Soil-Gas	Total Hazard Index
All of Parcel 181	**0-8.0**	$1x10^{-5}$	$4x10^{-6}$	$7x10^{-10}$	$1x10^{-5}$	$1x10^{-5}$	0.02	0.5	0.0002	0.5
Northern Parcel	**0-8.0**	$2x10^{-5}$	$4x10^{-6}$	$7x10^{-10}$	$2x10^{-5}$	$2x10^{-5}$	0.05	0.5	0.0002	0.6
Southern Parcel	**0-8.0**	$3x10^{-6}$	$4x10^{-6}$	$7x10^{-10}$	$7x10^{-6}$	$3x10^{-6}$	0.003	0.5	0.0002	0.5

PAH denotes polynuclear aromatic hydrocarbon

Northern and southern areas defined on the basis of similar soil benzo(a)pyrene-equivalent concentrations from 4 to 8 feet depth.

Risk and hazard for metals in soil at each depth calculated using an exposure point concentration for data across all of Parcel 181.

Risk and hazard for volatile organic compounds (VOC) calculated using maximum reported value in Parcel 181, using the greater of soil gas, hydropunch groundwater, or monitoring well groundwater samples; the hydropunch samples yielded both the maximum cancer risk and the maximum hazard index.

Incremental cancer risk is equivalent to the total risk minus the risk due to metals in soil.

- For Area 7, the estimated cancer risk ranges from 7×10^{-5} (0 to 4 feet depth interval) to 1×10^{-4} (0 to 0.5 feet depth interval) for the EPA methodology and is 1×10^{-4} (all depth intervals) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

For all decision areas, the major pathways of concern are incidental ingestion of soil and dermal contact with soil. The estimated cancer risks for all decision areas and depths fell into the target risk range of 1×10^{-6} to 1×10^{-4}. All estimated noncancer HIs were below the target of one.

Metals. As discussed in Section 4.0, an evaluation of the spatial distribution of metals within Parcel 181 revealed only slight spatial patterns. Therefore, the metals data collected at the site were not separated by decision areas, but were instead combined and evaluated for each depth interval. The estimated cancer risks and noncancer HIs for potential current residential exposure to metals in soil are summarized in Tables 5-40 and 5-47 by depth, respectively. Tables 5-40, 5-42, 5-44, and 5-46 provide these results based on EPA methodology and Tables 5-41, 5-43, 5-45, and 5-47 provide these results based on CalEPA methodology.

Based on EPA methodology (Table 5-40), the estimated cancer risk for a current residential scenario due to potential exposure to metals in soils ranged from 7×10^{-6} (0 to 0.5 feet bgs and 0 to 2 feet bgs) to 8×10^{-6} (0 to 4 feet bgs) for a child. The estimated cancer risk for an adult ranges from 8×10^{-7} (0 to 0.5 feet bgs and 0 to 2 feet bgs) to 9×10^{-7} (0 to 4 feet bgs). Based on CalEPA methodology (Table 5-41), the estimated cancer risk for a current residential scenario due to potential exposure to metals in soils is 8×10^{-6} for all three-depth intervals for a child. The estimated cancer risk for an adult ranges from 9×10^{-7} (0 to 0.5 feet bgs and 0 to 2 feet bgs) to 1×10^{-6} (0 to 4 feet bgs).

The estimated cancer risks are presented by chemical and depth in Appendix C, Tables C2-31 through C2-33 (EPA methodology) and Tables C3-31 through C3-33 (CalEPA methodology). As shown in these tables, the major chemical contributor to the estimated cancer risk is arsenic. The next highest major contributor is hexavalent chromium with an estimated cancer risk of approximately 1×10^{-8} (EPA methodology for all depth intervals) and 2×10^{-7} (CalEPA methodology for 0 to 4 feet bgs). As discussed in Section 5.9.5, arsenic concentrations detected in soil at the site are consistent with background soil concentrations.

As shown in Table 5-46 and 47, for noncancer health effects, the estimated HIs are less than one for both a child and adult. The maximum detected concentration of lead, 92.6 mg/kg, was well below the EPA Region 9 PRG for lead of 400 mg/kg for residential soil. For metals, incidental soil ingestion is the major contributing pathway.

5.9.2.2 Subsurface Soil/Shallow Groundwater

Exposure to chemicals in subsurface soil and shallow groundwater is limited to the inhalation of VOCs that have migrated through the overlying soil into indoor and ambient air. Only the inhalation of VOCs in indoor air was modeled for residential populations since outdoor concentrations of VOCs will be lower than indoor air concentrations due to higher mixing in the ambient environment.

As discussed in Section 5.7, soil gas data collected at the site was used to evaluate potential VOCs migrating from subsurface soil and groundwater. The screening evaluation was conducted using the maximum detected concentration for each chemical detected. The estimated cancer risks and noncancer HIs were shown in Tables 5-52 and 53 for the maximum concentrations detected in Parcel 181. Table 5-52 provides these results based on EPA methodology and Table 5-53 provides these results based on CalEPA methodology.

As shown in Table 5-52 and Table 5-53, the cancer risk for the maximum soil gas concentrations detected in Parcel 181 is 1 x 10^{-8} (EPA methodology – child) and 3 x 10^{-9} (CalEPA methodology – adult). The estimated HIs are below one for both methodologies. As these estimated cancer risks are below the low end of the target range and the noncancer HIs are well below one, no further refinement of the risk calculations was conducted for the residential scenario.

5.9.3 Cancer Risks and Chronic Noncancer Hazard Indices for Future Residents

This section presents the results of the risk calculations for the potential future residents. Potential media of concern for these populations include surface soil, subsurface soil, and shallow groundwater. Section 5.9.3.1 discusses the estimated cancer and noncancer HIs for surface soil. Subsurface soil and groundwater are combined in Section 5.9.3.2 that discusses potential migration of VOCs into indoor air.

5.9.3.1 Surface Soil

As discussed in Section 5.5, future on-site residents could be exposed directly to PAHs and metals remaining in surface soil on site. Potential routes of exposure for these populations would include incidental ingestion, dermal contact, and inhalation of windblown particulates. The exposure duration for a future resident is 30 years. For future residents, the 0 to 0.5 feet bgs interval is the most likely depth for direct contact if the current buildings remain. The 0 to 2 foot interval and 0 to 4 foot interval were evaluated assuming that soils may be mixed to these depths during redevelopment activities. Although the 0 to 8 foot depth interval has been included in this assessment, it is considered unlikely that future redevelopment activities would mix soils to this

depth over significant areas of the site. Estimated cancer risks and noncancer HIs for direct future residential exposure to surface soils is discussed below for PAHs and metals separately.

Polynuclear Aromatic Hydrocarbons. The estimated cancer risks and noncancer HIs for potential future residential exposure to PAHs in soil were summarized in Tables 5-30, 5-31, 5-36, and 5-37 by decision area, respectively. Tables 5-30 and 5-36 provide these results based on EPA methodology and Tables 5-31 and 5-37 provide these results based on CalEPA methodology. To calculate cancer risks, the chemical concentrations were converted to BaP-equivalent concentrations, as discussed in Section 3.0. The estimated HIs are presented by chemical and depth in Appendix C, Tables C2-1 through C2-28 (EPA methodology) and Tables C3-1 through C3-28 (CalEPA methodology). Each decision area is discussed separately below.

- For Area 1, the estimated cancer risk ranges from 8×10^{-6} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 2×10^{-5} (0 to 0.5 feet depth interval) for the EPA methodology and from 1×10^{-5} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 3×10^{-5} (0 to 0.5 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 2, the estimated cancer risk ranges from 3×10^{-5} (for the 0 to 2 feet depth interval) to 2×10^{-4} (0 to 8 feet depth interval) for the EPA methodology and from 5×10^{-5} (for the 0 to 2 feet depth interval) to 2×10^{-4} (0 to 8 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 3, the estimated cancer risk the estimated cancer risk ranges from 1×10^{-5} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 2×10^{-4} (0 to 8 feet depth interval) for the EPA methodology and from 2×10^{-5} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 3×10^{-4} (0 to 8 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 4, the estimated cancer risk ranges from 5×10^{-5} (for both the 0 to 0.5 and 0 to 2 feet depth intervals) to 8×10^{-5} (0 to 8 feet depth interval) for the EPA methodology and from 7×10^{-5} (for both the 0 to 0.5 and 0 to 2 feet depth intervals) to 1×10^{-4} (0 to 8 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 5, the estimated cancer risk ranges from 4×10^{-5} (for 0 to 8 feet depth intervals) to 7×10^{-5} (0 to 4 feet depth interval) for the EPA methodology and from 6×10^{-5} (for both the 0 to 8 feet depth intervals) to 1×10^{-4} (0 to 4 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

- For Area 6, the estimated cancer risk ranges from 2×10^{-5} (for 0 to 0.5 feet depth intervals) to 2×10^{-4} (0 to 8 feet depth interval) for the EPA methodology and from 3×10^{-5} (for both the 0 to 0.5 feet depth intervals) to 3×10^{-4} (0 to 8 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.
- For Area 7, the estimated cancer risk ranges from 1×10^{-4} (for both the 0 to 2 and 0 to 4 feet depth intervals) to 1×10^{-3} (0 to 8 feet depth interval) for the EPA methodology and from 2×10^{-4} (for the 0 to 0.5 feet depth interval, 0 to 2 feet depth interval, and 0 to 4 feet depth intervals) to 2×10^{-3} (0 to 8 feet depth interval) for the CalEPA methodology. For both methods, the estimated noncancer HIs for all depths are less than 1 for both the child and adult.

For all decision areas, the major pathways of concern are incidental ingestion of soil and dermal contact with soil. The estimated cancer risks for all decision areas and depths fell into the target risk range of 1×10^{-6} to 1×10^{-4}, except Area 2 (0 to 8 foot bgs), Area 3 (0 to 8 feet bgs), Area 6 (0 to 8 feet bgs) and Area 7 (0 to 0.5 feet bgs and 0 to 8 feet bgs for the EPA methodology, all depths for the CalEPA methodology). All estimated noncancer HIs were below the target of one.

Metals. As discussed in Section 4.0, an evaluation of the spatial distribution of metals within Parcel 181 revealed only slight spatial patterns. Therefore, the metals data collected at the site were not separated by decision areas, but were instead combined and evaluated for each depth interval. The estimated cancer risks and noncancer HIs for potential future residential exposure to metals in soil are summarized in Tables 5-42, 5-43, 5-48, and 5-49 by depth, respectively. Tables 5-42 and 5-48 provide these results based on EPA methodology and Tables 5-43 and 5-49 provide these results based on CalEPA methodology.

As summarized in Table 5-42 and Table 5-43, the estimated cancer risk for a future residential scenario due to potential exposure to metals in soils is approximately 1×10^{-5} for all depths by both EPA and CalEPA methodology. The estimated cancer risks are presented by chemical and depth in Appendix C, Tables C2-34 through C2-37 (EPA methodology) and Tables C3-34 and C3-37 (CalEPA methodology). As shown in these tables, the major chemical contributor to the estimated cancer risk is arsenic. The next highest major contributor is hexavalent chromium with an estimated cancer risk ranging from 3×10^{-8} to 4×10^{-8} (EPA methodology) and from 3×10^{-7} to 5×10^{-7} (CalEPA methodology). As discussed in Section 5.9.5, arsenic concentrations detected in soil at the site are consistent with background soil concentrations.

As shown in Table 5-48 and Table 5-49, for noncancer health effects the estimated HIs for a child resident were the highest. The estimated noncancer HIs for a child resident ranged from 0.7 (0 to 0.5 feet bgs and 0 to 2 feet bgs) to 1 (0 to 8 feet bgs) for both the EPA and CalEPA

methodology. These estimated noncancer HIs are presented by chemical and depth in Appendix C, Tables C2-39 through C2-42 (EPA methodology) and Tables C3-39 through C3-42 (CalEPA methodology). All estimated noncancer HIs were at or below the target of one. In addition, the maximum detected concentration of lead, 92.6 mg/kg, was well below the EPA Region 9 PRG for lead of 400 mg/kg for residential soil. For metals, incidental ingestion is the major pathway of concern.

5.9.3.2 Subsurface Soil/Shallow Groundwater

Exposure to chemicals in subsurface soil and shallow groundwater is limited to the inhalation of VOCs that have migrated through the overlying soil into indoor and ambient air. Only the inhalation of VOCs in indoor air was modeled for residential populations since outdoor concentrations of VOCs will be lower than indoor air concentrations due to higher mixing in the ambient environment.

Soil gas data collected at the site was used to evaluate potential VOCs migrating from subsurface soil and groundwater. Because the soil gas samples are distributed both on-site and off site, a screening evaluation was conducted to determine the significance of this potential exposure pathway. The screening evaluation was conducted using the maximum detected concentration for each chemical detected. The estimated cancer risks and noncancer HIs were shown in Tables 5-54 and 5-55 for the maximum concentrations detected in Parcel 181 and in Tables 5-56 and 5-57 for the maximum concentration detected off site. Tables 5-54 and 5-56 provide these results based on EPA methodology and Tables 5-55 and 5-57 provide these results based on CalEPA methodology.

As shown in Table 5-54 and Table 5-55, the cancer risk for the maximum soil gas concentrations detected in Parcel 181 is 4×10^{-8} (EPA methodology and 2×10^{-8} (CalEPA methodology). The HIs are below one for both methodologies. As shown in Table 5-56 and Table 5-57, the cancer risk for the maximum soil gas concentrations detected in off site properties is 9×10^{-8} (EPA methodology) and 4×10^{-8} (CalEPA methodology). The HIs are below one for both methodologies. As these estimated cancer risks are below the low end of the target range and the noncancer HIs are well below one, no further refinement of the risk calculations was conducted for a future residential on-site or off site scenario.

5.9.4 Cancer Risks and Noncancer Hazard Indices for Construction Workers

This section presents the results of the risk calculations for the construction worker. Similar to the residents, potential media of concern for this population includes surface soil, subsurface soil, and shallow groundwater. Section 5.9.4.1 discusses the estimated cancer and noncancer HIs for

surface soil. Subsurface soil and groundwater are combined in Section 5.9.4.2 that discusses potential migration of VOCs into trench air.

5.9.4.1 Surface Soil

As discussed in Section 5.5, construction workers could be exposed directly to PAHs and metals remaining in surface soil on site during future development activities. Potential routes of exposure for this population would include incidental ingestion, dermal contact, and inhalation of windblown particulates. For direct construction worker contact with soil, the soil depth interval is defined as 0 to 8 feet bgs. This depth was chosen, as it is possible that utility lines could reach this depth. Estimated cancer risks and noncancer HIs for direct construction worker exposure to soils is discussed below for PAHs and metals separately.

Polynuclear Aromatic Hydrocarbon. As discussed in Section 5.7, the seven decision areas used to evaluate residents were not used for the construction worker, as they are unlikely to limit their activities to only these areas. For construction workers, PAHs in soil were evaluated across Parcel 181 and the subdivided Northern and Southern Parcels discussed in Appendix B. The estimated cancer risks and noncancer HIs for potential construction worker exposure to PAHs in soil are summarized in Tables 5-32, 5-33, 5-38, and 5-39, respectively. Tables 5-32 and 5-38 provide these results based on EPA methodology and Tables 5-33 and 5-39 provide these results based on CalEPA methodology. To calculate cancer risks, the chemical concentrations were converted to BaP-equivalent concentrations, as discussed in Section 3.0. The estimated HIs are presented by chemical and depth in Appendix C, Tables C2-29 and C2-30 (EPA methodology) and Tables C3-29 and C3-30 (CalEPA methodology). Parcel 181, the Northern Parcel, and the Southern Parcel are discussed separately below.

- For Parcel 181, the estimated cancer risk is 3×10^{-6} (EPA methodology) and 9×10^{-6} (CalEPA methodology). The estimated noncancer HI is less than 1.
- For the Northern Parcel, the estimated cancer risk is 6×10^{-6} (EPA methodology) and 2×10^{-5} (CalEPA methodology). The estimated noncancer HI is less than 1.
- For the Southern Parcel, the estimated cancer risk is 8×10^{-7} (EPA methodology) and 2×10^{-6} (CalEPA methodology). The estimated noncancer HI is less than 1.

The estimated cancer risks for Parcel 181 and the Northern Parcel fall into the target risk range of 1×10^{-6} to 1×10^{-4}. For the Southern Parcel, the estimated cancer risk is at the lowest end of the target range. The incidental ingestion and dermal contact pathways primarily drove the risk estimates. All estimated noncancer HIs were below the target of one.

Metals. The estimated cancer risks and noncancer HIs for potential construction worker exposure to metals in soil were summarized in Tables 5-44, 5-45, 5-50, and 5-51, respectively. Tables 5-44 and 5-50 provide these results based on EPA methodology and Tables 5-45 and 5-51 provide these results based on CalEPA methodology.

Based on EPA methodology (Table 5-44), the estimated cancer risk associated with metals for a construction worker scenario is 7×10^{-7}. Based on CalEPA methodology (Table 5-45), the estimated cancer risk associated with metals for a construction worker scenario is 4×10^{-6}. The estimated cancer risks are presented by chemical in Appendix C, Table C2-38 (EPA methodology) and Table C3-38 (CalEPA methodology). As shown in this table, the major chemical contributors to the estimated cancer risks for the EPA methodology are arsenic (3×10^{-7}) and hexavalent chromium (3×10^{-7}). The major chemical contributor to the estimated cancer risk for the CalEPA methodology is hexavalent chromium (4×10^{-6}).

As shown in Table 5-50 and Table 5-51, for noncancer health effects, the estimated noncancer HI for a construction worker is 0.5, below the target of one. As with cancer risk, the major contributing pathways are inhalation of soil particulates and incidental ingestion. The estimated noncancer HI is presented by chemical in Appendix C, Table C2-43 (EPA methodology) and in Table C3-43 (CalEPA methodology), which shows nickel as the major chemical contributor. The maximum detected concentration of lead, 92.6 mg/kg, was well below the EPA Region 9 PRG for lead of 750 mg/kg for industrial soil, as well as the 400 mg/kg for residential soil.

5.9.4.2 Subsurface Soil/Shallow Groundwater

As discussed in Section 5.5, the construction worker could be exposed to VOCs in subsurface soil and shallow groundwater (considered less than 12 feet) that migrate as vapors into a trench during construction activities. Inhalation risks were calculated using chemical concentrations in both soil-gas and shallow groundwater because VOC concentrations in these media were poorly correlated and because the trench may extend in depth to the water table.

For both soil gas and groundwater, screening evaluations were conducted to determine the significance of these pathways. The screening evaluation was conducted using the maximum detected concentration for each chemical detected. The estimated cancer risks and noncancer HIs are shown in Table 5-58 and Table 5-59 for the maximum soil gas concentrations detected in Parcel 181 and in Table 5-60 and Table 5-61 for the maximum soil gas concentration detected whether it was located on-site or off site. Tables 5-58 and 5-60 provide these results based on EPA methodology and Tables 5-59 and 5-61 provide these results based on CalEPA methodology.

As shown in Table 5-58 and Table 5-59, the estimated cancer risk for the maximum soil gas concentrations detected in Parcel 181 ranges from 5×10^{-11} (CalEPA methodology) to 8×10^{-11} (EPA methodology) and the HI ranges from 0.00003 (CalEPA methodology) to 0.0007 (EPA methodology) for the construction worker scenario. As shown in Table 5-60 and Table 5-61, the estimated cancer risk for the maximum soil gas concentration off site ranges from 1×10^{-10} (CalEPA methodology) to 2×10^{-10} (EPA methodology) and the HI ranges from 0.0001 (CalEPA methodology) to 0.002 (EPA methodology). Because these estimated cancer risks are below the low end of the target range and the noncancer HIs are well below one, no further refinement of the soil gas risk calculations was conducted for the construction worker.

The estimated cancer risks and noncancer HIs were shown in Table 5-62 and Table 5-63 for the maximum shallow groundwater concentrations detected in Parcel 181 direct-push samples and in Table 5-64 and Table 5-65 for the maximum shallow groundwater concentration detected in off site direct-push samples. Tables 5-62 and 5-64 provide these results based on EPA methodology and Tables 5-63 and 5-65 provide these results based on CalEPA methodology. As shown in Table 5-62 and Table 5-63, the estimated cancer risk for the maximum shallow groundwater concentrations detected in Parcel 181 direct-push samples ranges from 2×10^{-10} (EPA methodology) to 7×10^{-10} (CalEPA methodology) and the HI ranges from 0.0002 (CalEPA methodology) to 0.0008 (EPA methodology). As shown in Table 5-64 and Table 5-65, the estimated cancer risk for the maximum shallow groundwater concentration in off site direct-push samples ranges from 2×10^{-9} (EPA methodology) to 9×10^{-9} (CalEPA methodology) and the HI ranges from 0.001 (CalEPA methodology) to 0.005 (EPA methodology).

Chemical concentrations from monitoring wells, which are also indicative of shallow groundwater, were also used to calculate cancer risks and noncancer HIs for construction workers. The estimated cancer risks and noncancer HIs were shown in Table 5-66 and Table 5-67 for the maximum shallow groundwater concentrations detected in Parcel 181 monitoring wells and in Table 5-68 and Table 5-69 for the maximum shallow groundwater concentrations detected in off site monitoring wells. Tables 5-66 and 5-68 provide these results based on EPA methodology and Tables 5-67 and 5-69 provide these results based on CalEPA methodology. As shown in Table 5-66 and Table 5-67, the estimated cancer risk for the maximum shallow groundwater concentration detected in the Parcel 181 monitoring wells ranges is 5×10^{-12} and the HI is 0.00006 for both methods (EPA and CalEPA). As shown in Table 5-68 and Table 5-69, the estimated cancer risk for the maximum shallow groundwater concentrations in off site monitoring wells ranges from 3×10^{-8} (EPA methodology) to 1×10^{-7} (CalEPA methodology) and the HI ranges from 0.01 (CalEPA methodology) to 0.07 (EPA methodology).

Because these estimated cancer risks are below the low end of the target range and the noncancer HIs are well below one, no further refinement of the shallow groundwater risk calculations was conducted for the construction worker.

5.9.5 Risk Associated With Background or Ambient Concentrations

Residential and construction worker cancer risks and HIs were evaluated for PAHs in soil, metals in soil, and VOCs migrating from soil gas and shallow groundwater into air. Ambient or background concentrations exist for each of these three types of chemical constituents in urban or suburban environments. Polynuclear aromatic hydrocarbons are created in the natural environment due to fire, although in more urban areas the combustion of petroleum fuels is likely to be a more important source. Like PAHs, many VOCs have both natural and anthropogenic sources. In urban areas, VOCs such as benzene, toluene, ethylbenzene, and xylene (BTEX) compounds in ambient air are primarily associated with anthropogenic sources such as vehicle emissions and industrial facilities. Metallic elements occur naturally in the earth's crust at concentrations that vary based on local geology, although they too may have enhanced concentrations in urban and suburban soil.

Development of an appropriate ambient data set for PAHs in soil in the San Francisco Bay area is presently the subject of an effort involving regional environmental government agencies. However, such a data set was not available at the time this report was prepared. Identification of ambient air data for VOCs was not undertaken for this report because, as shown in Sections 5.9.2 through 5.9.4, the estimated cancer risks and noncancer HIs related to VOC inhalation are negligible. Applicable ambient data for metals in soil are available; these data are the subject of the remainder of this subsection.

As arsenic was the only metal with an estimated cancer risk of greater than 1×10^{-6} for a residential scenario, this chemical was further evaluated by comparison to expected background concentrations. As presented in Appendix B, Figure B-11 compares the OU-5 arsenic values to several Alameda ambient metals data sets, and to the Regional Monitoring Program/Bay Protection and Toxic Cleanup Program ambient station arsenic data. This figure shows that OU-5 arsenic levels are consistent with the ambient levels present at various locations across Alameda Point (using the pink-central, blue-southeastern, and yellow-northwestern ambient data sets for Alameda previously proposed by PRC Environmental Management, Inc. [1997] and generally accepted by the agencies [e.g., April 5, 2001 Comments from EPA]), and well within ambient arsenic concentrations in San Francisco Bay sediments.

5.9.6 Risk Summary for Residents and Construction Workers

Tables 5-70 through 5-75 provide a summary of total cancer risk, incremental cancer risk, and noncancer HIs for the current residential, future residential, and construction worker scenarios for Parcel 181 at OU-5. Tables 5-70, 5-72, and 5-74 provide these results based on EPA methodology and Tables 5-71, 5-73, and 5-75 provide these results based on CalEPA methodology.

Total cancer risk is calculated as the sum of risks related to exposure to PAHs in soil, metals in soil, and VOCs in soil gas and/or shallow groundwater. As discussed in previous sections of this report, cancer risk associated with metals in soil is almost wholly due to arsenic, which is found at concentrations consistent with ambient levels. Because applicable information on ambient concentrations of PAHs were unavailable when this report was prepared, the incremental cancer risk shown in Tables 5-70 through 5-75 is simply equivalent to the total risk minus the risk due to metals in soil.

The seven decision areas for which cancer risk values were developed are based on the spatial distribution of soil BaP-equivalent concentrations within 4 feet of the ground surface. This process is discussed in Section 5.7 of this report and presented in detail in Appendix B. Residential scenario BaP-equivalent EPCs for the 0 to 0.5 feet, 0 to 2 feet, and 0 to 4 feet depth intervals are fully supported by the available data.

Fewer BaP-equivalent concentration soil data were obtained in the 4 to 8 feet depth interval. As shown in Figure B-6, the limited BaP-equivalent concentration data in the 4 to 8 feet layer suggest that the seven decision areas do not apply at this depth interval. Consequently, there is less confidence in the BaP-equivalent EPCs for the 0 to 8 foot depth interval, and calculated differences in PAH-related cancer risk or noncancer HIs among the seven decision areas are not as meaningful as those calculated for depth intervals above 4 feet. In addition, it is considered unlikely that redevelopment activities would mix soils to this depth over significant areas of the site.

As described in Section 5.7, EPCs for metals at each depth interval were calculated across all seven-decision areas because no discernible patterns were evident in a lateral dimension. No EPCs were developed for VOCs in soil gas or groundwater because even when employing maximum detected values in the risk assessment, the potential health effects from VOC inhalation were negligible. For the potential migration of VOCs into a trench, the values reported in Table 5-74 and 5-75 are the higher of those calculated using either the shallow groundwater (maximum depth of 12 feet) or soil gas VOC source terms. This was done because

the trench may extend to the water table. For the residential indoor air pathway, only VOCs in soil gas were used as input to the cancer risk and noncancer HI calculations.

As discussed in Section 2.0, the Navy conducted a TCRA in decision areas 4, 5, and 7 of Parcel 181 during winter 2001 and spring 2002. The TCRA removed soils to a depth of 2 feet bgs, backfilled with clean imported soil, topsoil and sod. To evaluate the potential need for further controls in these areas, such as restrictions to digging at depth, this risk assessment also evaluated the potential risk to contacting deeper soils once the top 2 feet has been removed.

Tables 5-76, 5-77, 5-78, and 5-79 show the estimated cancer risks for potential current and future residential exposure to soils at the 2 to 4 foot depth interval and 2 to 8 foot depth interval in these three decision areas. Only decision area 7 increases with the larger depth interval. Based on EPA methodology (Table 5-76 and 5-78), the estimated cancer risks for a current resident fall within the 10^{-6} to 10^{-4} risk range for all areas except decision area 7 for the 2 to 8 foot interval. For future residents, decision area 5 for the 2 to 4 foot interval and decision area 7 for both the 2 to 4 and 2 to 8 foot intervals exceed the upper end of the risk range. Based on CalEPA methodology (Table 5-77 and 5-79), the estimated cancer risks for a current resident fall within the 10^{-6} to 10^{-4} risk range for all areas except decision area 5 for the 2 to 4 foot bgs interval and decision area 7 for both the 2 to 4 foot bgs and 2 to 8 foot bgs intervals. For future residents, all areas except decision area 5 for the 2 to 8 foot bgs interval exceed the upper end of the risk range.

In the ROD for the site, the Navy intends to restrict digging below 2 feet across all of OU-5. The TCRA and restriction to digging will effectively eliminate the potential site-related risks due to direct contact with PAHs in near surface soils (0 to 2 feet bgs) in these areas.

5.9.7 Screening Assessment for Soils in Off Site Properties

Soil samples were collected in October 2001 in order to evaluate Parcels 179 (Miller Elementary School) and Parcel 180 (Alameda Child Development Center). As discussed in Section 3.0 of this report, this sample collection effort was not specified in the OU-5 Work Plan but arose in discussions among the Navy, Coast Guard, and School Board. The PAH data obtained from these samples is of a preliminary nature with respect to establishing the extent of PAH contamination, average PAH soil concentrations, and any associated human health risk. Consequently, these data are evaluated in a screening-level evaluation in this section by comparison of the individual sample results to EPA Region 9 PRGs for residential soil. These PRGs combine current EPA toxicity values with "standard" exposure factors to estimate concentrations in environmental media that are considered protective of humans, including

sensitive groups, over a lifetime. The PRGs correspond to a cancer risk of one-in-one million (10^{-6}) and a noncancer hazard index of one.

For this evaluation, twenty-two soil samples were collected from nine locations. Three locations were sampled in the southeast portion of Parcel 180 and three locations were sampled in the western portion of Parcel 179. As the eastern portion of Parcel 179 was covered with asphalt, three locations in Parcel 181 just adjacent to the asphalt parking lot on the eastern boundary of Parcel 179 were also sampled. Samples in Parcel 179 were collected only from a 0 to 0.5 foot depth interval. In Parcel 180, three samples were also collected from a 0.5 to 2 foot depth interval, two samples from a 2 to 4 foot interval, and one sample from a 4 to 8 foot interval. In the three Parcel 181 samples collected adjacent to the asphalt parking lot, all locations were sampled in the top three depth intervals but only one sample was collected from the 4 to 8 foot depth interval. Sample locations and BaP-equivalent concentrations are shown in Figures 4-5 through 4-8 of this RI Report.

The BaP-equivalent concentrations at each sample location and depth interval are presented in Table 5-80, "Screening of Off Site Benzo(a)Pyrene-Equivalent Concentrations (milligrams per kilogram)." Detected BaP concentrations that exceed the EPA Region 9 PRG for residential soil of 0.062 mg/kg are shown in bold font style in this table.

Only two samples had a BaP-equivalent concentration below the EPA Region 9 PRG for residential soil of 0.062 mg/kg. As discussed in Section 5.9.1, the range of cancer risk values within which risk management decisions are typically made is between 1×10^{-6} and 1×10^{-4}. Only one BaP-equivalent concentration (Location OU5-174 at 2 to 4 feet depth) approaches a soil concentration of 6.2 mg/kg, which is the equivalent of the PRG value calculated using a cancer risk threshold of 1×10^{-4}.

5.9.8 Uncertainty Assessment

The estimated cancer risks and noncancer HIs presented in this risk assessment are based on numerous assumptions, most of which are considered conservative. Both generic and site specific assumptions are used to estimate the EPCs, human exposure factors, chemical toxicity, and associated cancer and noncancer health risks. As a result of the cumulative effects of these conservative assumptions, the calculated risks are likely to overestimate actual risks.

Some of the assumptions used in this risk assessment are particularly uncertain or have a particularly strong influence on the estimated risks. The following section summarizes some of the uncertainties resulting from various assumptions used in the risk assessment.

Table 5-76
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Time-Critical Removal Action Areas - Current Residents - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk							
			Current Adult Resident				Current Child Resident			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
4	2.0-4.0	7.54	$4.2x10^{-10}$	$6.5x10^{-6}$	$3.4x10^{-6}$	**$1x10^{-5}$**	$9.7x10^{-10}$	$6.0x10^{-5}$	$2.2x10^{-5}$	**$8x10^{-5}$**
4	2.0-8.0	6.24	$3.5x10^{-10}$	$5.3x10^{-6}$	$2.8x10^{-6}$	**$8x10^{-6}$**	$8.1x10^{-10}$	$5.0x10^{-5}$	$1.8x10^{-5}$	**$7x10^{-5}$**
5	2.0-4.0	10.33	$5.7x10^{-10}$	$8.9x10^{-6}$	$4.6x10^{-6}$	**$1x10^{-5}$**	$1.3x10^{-9}$	$8.3x10^{-5}$	$3.0x10^{-5}$	**$1x10^{-4}$**
5	2.0-8.0	2.47	$1.4x10^{-10}$	$2.1x10^{-6}$	$1.1x10^{-6}$	**$3x10^{-6}$**	$3.2x10^{-10}$	$2.0x10^{-5}$	$7.2x10^{-6}$	**$3x10^{-5}$**
7	2.0-4.0	11.42	$6.3x10^{-10}$	$9.8x10^{-6}$	$5.1x10^{-6}$	**$1x10^{-5}$**	$1.5x10^{-9}$	$9.1x10^{-5}$	$3.3x10^{-5}$	**$1x10^{-4}$**
7	2.0-8.0	100.88	$5.6x10^{-9}$	$8.6x10^{-5}$	$4.5x10^{-5}$	**$1x10^{-4}$**	$1.3x10^{-8}$	$8.1x10^{-4}$	$2.9x10^{-4}$	**$1x10^{-3}$**

mg/kg denotes milligrams per kilogram

Table 5-77

Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Time-Critical Removal Action Areas - Current Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk							
			Current Adult Resident				Current Child Resident			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways	Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
4	2.0-4.0	7.54	$5.2x10^{-10}$	$1.1x10^{-5}$	$5.5x10^{-6}$	**$2x10^{-5}$**	$1.2x10^{-9}$	$9.9x10^{-5}$	$3.7x10^{-5}$	**$1x10^{-4}$**
4	2.0-8.0	6.24	$4.3x10^{-10}$	$8.8x10^{-6}$	$4.6x10^{-6}$	**$1x10^{-5}$**	$1.0x10^{-9}$	$8.2x10^{-5}$	$3.1x10^{-5}$	**$1x10^{-4}$**
5	2.0-4.0	10.33	$7.2x10^{-10}$	$1.5x10^{-5}$	$7.5x10^{-6}$	**$2x10^{-5}$**	$1.7x10^{-9}$	$1.4x10^{-4}$	$5.1x10^{-5}$	**$2x10^{-4}$**
5	2.0-8.0	2.47	$1.7x10^{-10}$	$3.5x10^{-6}$	$1.8x10^{-6}$	**$5x10^{-6}$**	$4.0x10^{-10}$	$3.2x10^{-5}$	$1.2x10^{-5}$	**$4x10^{-5}$**
7	2.0-4.0	11.42	$7.9x10^{-10}$	$1.6x10^{-5}$	$8.3x10^{-6}$	**$2x10^{-5}$**	$1.9x10^{-9}$	$1.5x10^{-4}$	$5.7x10^{-5}$	**$2x10^{-4}$**
7	2.0-8.0	100.88	$7.0x10^{-9}$	$1.4x10^{-4}$	$7.4x10^{-5}$	**$2x10^{-4}$**	$1.6x10^{-8}$	$1.3x10^{-3}$	$5.0x10^{-4}$	**$2x10^{-3}$**

mg/kg denotes milligrams per kilogram

Table 5-78
Summary of Estimated Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Time-Critical Removal Action Areas - Future Residents - EPA Methodology

Area	Depth Interval (feet)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
4	**2.0-4.0**	7.54	$2.6x10^{-9}$	$8.6x10^{-5}$	$3.5x10^{-5}$	**$1x10^{-4}$**
4	**2.0-8.0**	6.24	$2.2x10^{-9}$	$7.1x10^{-5}$	$2.9x10^{-5}$	**$1x10^{-4}$**
5	**2.0-4.0**	10.33	$3.6x10^{-9}$	$1.2x10^{-4}$	$4.8x10^{-5}$	**$2x10^{-4}$**
5	**2.0-8.0**	2.47	$8.6x10^{-10}$	$2.8x10^{-5}$	$1.2x10^{-5}$	**$4x10^{-5}$**
7	**2.0-4.0**	11.42	$4.0x10^{-9}$	$1.3x10^{-4}$	$5.4x10^{-5}$	**$2x10^{-4}$**
7	**2.0-8.0**	100.88	$3.5x10^{-8}$	$1.2x10^{-3}$	$4.7x10^{-4}$	**$2x10^{-3}$**

mg/kg denotes milligrams per kilogram

Table 5-79
Summary of Pathway-Specific Cancer Risks for Polynuclear Aromatic Hydrocarbons in Soil - Time-Critical Removal Action Areas - Future Residents - CalEPA Methodology

Area	Depth Interval (feet bgs)	Exposure Point Concentration (mg/kg)	Estimated Cancer Risk			
			Future Resident (age-adjusted)			
			Inhalation of Soil Particulates	Incidental Ingestion of Soil	Dermal Contact with Soil	All Pathways
4	2.0-4.0	7.54	$3.3x10^{-9}$	$1.4x10^{-4}$	$5.9x10^{-5}$	**$2x10^{-4}$**
4	2.0-8.0	6.24	$2.7x10^{-9}$	$1.2x10^{-4}$	$4.9x10^{-5}$	**$2x10^{-4}$**
5	2.0-4.0	10.33	$4.6x10^{-9}$	$1.9x10^{-4}$	$8.1x10^{-5}$	**$3x10^{-4}$**
5	2.0-8.0	2.47	$1.1x10^{-9}$	$4.6x10^{-5}$	$1.9x10^{-5}$	**$7x10^{-5}$**
7	2.0-4.0	11.42	$5.0x10^{-9}$	$2.1x10^{-4}$	$9.0x10^{-5}$	**$3x10^{-4}$**
7	2.0-8.0	100.88	$4.4x10^{-8}$	$1.9x10^{-3}$	$8.0x10^{-4}$	**$3x10^{-3}$**

bgs denotes below ground surface
mg/kg denotes milligrams per kilogram

Table 5-80
Screening of Off Site Benzo(a)Pyrene-Equivalent Concentrations (milligrams per kilogram)*

Location ID	Depth Interval (feet)			
	0-0.5	0.5-2.0	2.0-4.0	4.0-8.0
Alameda Child Development Center (Parcel 180)				
OU5-172	**0.037**	.	NS	NS
OU5-173	0.018	**0.12**	**0.68**	**0.73**
OU5-174	**0.41**	**0.57**	**5.7**	NS
Miller Elementary School (Parcel 179)				
OU5-175	**0.74**	NS	NS	NS
OU5-176	**1.4**	NS	NS	NS
OU5-180	**0.77**	NS	NS	NS
Miller Elementary School (Parcel 181, adjacent to 179)				
OU5-177	**1.1**	**0.45**	**0.43**	NS
OU5-178	**0.51**	**0.071**	**0.14**	**0.95**
OU5-179	**1.1**	**0.37**	**0.081**	NS

**Values that exceed U.S. Environmental Protection Agency Region IX Preliminary Remediation Goal of 0.062 milligrams per kilogram shown in bold.*
NS denotes not sampled
bgs denotes below ground surface

5.9.8.1 Exposure Assessment

Numerous assumptions are made in the estimation of human exposure to chemicals. These assumptions include the procedures used to generate EPCs discussed in Section 5.5, and parameters related to human activity patterns.

Exposure Point Concentrations. Exposure point concentrations were generated for a number of depth intervals and decision areas to support the evaluation of current and future exposure to chemicals detected in soil. As previously discussed, the assumption was made that the underlying statistical distribution for all COPCs was log normal, and procedures were used to estimate the 95 percent UCL on the log-transformed mean. The 95 percent UCLs for the log-transformed mean were used as the EPC except for the following cases:

- If the data were log normally distributed but the 95 percent UCL was greater than the overall maximum value. In this case, the EPC was set to the overall maximum value, regardless of detection status.
- If the data were highly censored (greater than 50 percent non-detects), or if the data did not fit either the normal or log normal distribution. In this case, the EPC was set to the minimum of the 95 percent UCL for the log-transformed mean or the maximum detected value.

For these cases, a bootstrap procedure was also performed to estimate the 95 percent UCL in order to evaluate the uncertainty associated with use of the maximum value. The bootstrap method utilizes the actual data as if it were the "true distribution," so no distributional assumptions are required. Using a computer simulation, random samples are taken repeatedly from the population of available results, and each random group of samples is used to calculate a mean. After completing the simulation an adequate number of times (typically a thousand runs), the estimated mean values are sorted from high to low, and the 95^{th} percentile of the sorted values is then selected as the UCL on the mean. Using the bootstrap procedure, a UCL higher than the maximum observed value would not be generated.

Sections 2.0 and 3.0 of Appendix B discuses the results of the bootstrap calculations and provides tables that compare the bootstrap UCL to the maximum values. The value of this exercise is it provides an indication of the uncertainty associated with defaulting to the maximum value. If the same decision would be made using the maximum or using the bootstrap UCL, then using the maximum is not overly conservative. In contrast, if the bootstrap UCL results in a risk estimate that would trigger an entirely different decision, the adequacy of the available data may be called into question. The true EPC is likely to be bounded by the log normal UCL and the bootstrap UCL values.

In almost all cases, the bootstrap UCLs were lower than the maximum values, and therefore the EPCs used in the risk evaluations were conservative, often by approximately a factor of two. Whether a factor of two difference in the risk estimate would result in a different decision, is a risk management issue, however in general the bootstrap was performed to evaluate the BaP-equivalent EPCs in the 0 to 8 foot depth interval, where the sample sizes were much smaller than in the top three intervals. The fact that the bootstrap versus log normal EPCs differ by a factor of two is a function of the limited number of samples taken from the 4 to 8 foot depth interval.

A visual comparison of Figures B-3.2 and B-6 in Appendix B reveals that while there is strong support for dividing the site into seven decision areas when evaluating BaP distributions in the top four feet, there is no such support for dividing the 4 to 8 foot depth interval into seven areas. Therefore, only a semi-quantitative analysis of exposure to deeper soils in the seven decision areas is supported by the available data. An evaluation of exposure to PAHs in the 0 to 8 foot interval over the entire site, or the two construction worker strata, is fully supported by the available data. In both the northern and southern construction worker strata the EPCs are either sufficiently high (in the north) or low (in the south) when factoring in the 4 to 8 foot depth interval, that a factor of two uncertainty would be unlikely to affect decision making with regard to BaP-equivalent concentration risk. Due to low detection frequencies, the bootstrap resulted in a slightly higher UCL than the log normal calculation for a few individual PAHs in various depth intervals. Metals for which bootstrap UCLs were calculated showed little difference between the EPC that was used and the bootstrap 95 percent UCL, indicating less uncertainty in the metals EPCs than those calculated for the individual PAHs.

In addition to comparing EPCs to bootstrap UCLs, an evaluation was done to determine the sensitivity of the EPC values to how non-detected values were treated in calculating BaP equivalents. A detailed discussion of this analysis is presented in Appendix B, with the results is presented in Table B-23. As previously discussed, one-half the sample specific reporting limit was substituted for non-detected PAHs. To evaluate the sensitivity to this substitution, EPCs were recalculated by substituting zeros, and by substituting the full reporting limits. The overall conclusion of this exercise was that the EPCs were not very sensitive to how non-detected values were treated. While the substitutions do result in different numbers, the difference was slight and would be unlikely to affect the decision made about a specific area or depth interval. In some cases when the full reporting limits were substituted, the EPC actually decreased (due to a reduction in variability), and when zeros were substituted the EPC increased (due to an increase in the variability). However, in the majority of cases, the EPC increased slightly when the full reporting limit was substituted in place of one-half the reporting limit.

Exposure Assumptions. Most of the exposure assumptions used in the calculation of risks and HIs are default assumptions recommended by EPA or CalEPA, and are often the upper 90^{th} or 95^{th} percentile values. The use of 90^{th} or 95^{th} percentile values, when available, is recommended by the EPA in order to estimate the "Reasonable Maximum Exposure" that may occur at a site. However, the combination of several upper-bound estimates used as exposure parameters to calculate chemical intake may substantially overestimate chemical intake. The risk and HIs calculated in this risk assessment are therefore likely to be greater than levels to which the evaluated populations would be exposed.

There were only a few differences between the exposure assumptions used for the EPA versus CalEPA methodology. These assumptions were the surface area for dermal contact (child and construction worker), the adherence factor (construction worker), and the absorption factor for PAHs. The most significant differences are for the construction worker. The surface area for dermal contact for a construction worker is 3,300 cm^2/day for the EPA methodology and 5,700 cm^2/day for the CalEPA methodology, almost a factor of two. The adherence factor for a construction worker is 0.2 mg/cm^2 for the EPA methodology and 0.8 mg/cm^2 for the CalEPA methodology, a factor of four.

Vegetable Uptake. For this risk assessment, the vegetable uptake exposure pathway was not quantitatively evaluated. Currently, there are restrictions in place to prevent Coast Guard personnel and their families from planting vegetables and otherwise digging on the property. In the ROD for the site, the Navy intends to restrict digging below 2 feet across all of OU-5. The TCRA and restriction to digging will effectively eliminate the potential site-related risks due to direct contact with PAHs in near surface soils (0 to 2 feet bgs) in these areas.

Five of the seven PAHs identified as carcinogens (benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene) consist of five or more rings. Polynuclear aromatic hydrocarbons containing five or more rings may sorb to plant roots; however, these are not expected to translocate to foliage in other than trace amounts (EPRI, 1992). Thus, uptake and accumulation of PAHs containing five or more rings is not expected to occur.

Polynuclear aromatic hydrocarbons consisting of two, three, or four rings have the greatest potential for uptake by plants. Uptake of naphthalene, anthracene, and benz(a)anthracene (carcinogen) by roots has been reported in literature. In addition, eight PAHs consisting of three or four rings (acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene [carcinogen], and chrysene [carcinogen]) have been detected in the roots and

leaves of four plant species collected near a coal tar disposal trench in eastern Tennessee (EPRI, 1992).

In 1993, researchers measured individually the uptake of four radio-labeled PAHs (naphthalene, fluoranthene, phenanthrene, and pyrene [none of which are carcinogenic]) by white sweetclover under conservative conditions (EPRI, 1993). These specific PAHs were chosen based on their common occurrence at manufactured gas plant sites and their enhanced potential for plant uptake, given their chemical and physical characteristics. Researchers performed measurements by spiking soil with the radio-labeled PAHs then using radio-tracer techniques to quantify the amount of 14C taken up by the sweetclover grown in the treated soil. A composite soil with a total organic carbon content of less than 1 percent was chosen in order to maximize root uptake. At the end of the experiment, researchers determined the distribution of 14C among root, stem, and leaf tissues.

The results of this experiment showed that despite the use of experimental laboratory conditions selected to favor plant uptake, less than 0.8 percent of the total 14C-derived naphthalene recovered was found in aboveground foliage after a 5-day exposure. Additionally, less than 0.02 percent of the 14C derived from fluoranthene, phenanthrene, or pyrene moved from soil to aboveground foliage. Thus, the transport of PAHs from surface and subsurface soils to the food chain via plants is not likely to be an important pathway for exposure to PAHs in soils.

In light of the experimental results discussed above, it should be noted that five of the seven PAHs identified as carcinogens consist of five or more rings and thus, would not translocate to aboveground foliage in any significant amount. Only two PAHs identified as carcinogens (benz(a)anthracene and chrysene) consist of less than five rings. Both benz(a)anthracene and chrysene consist of four rings. In the experiment discussed above, less than 0.02 percent of 14C derived from fluoranthene and pyrene (i.e., PAHs consisting of four rings) was recovered from aboveground foliage. This would seem to indicate that the transport of carcinogenic PAHs from soils to the above ground portions of plants is not likely to be a significant pathway for exposure to PAHs in soils.

5.9.8.2 Fate and Transport Modeling

The uncertainties in the calculated emission flux of chemicals are associated with the limitations of the fate and transport models used in this assessment and a number of assumptions made during these calculations. First, there are inherent limitations in the models, which introduce uncertainties in the calculated flux. In particular, the modeling used in this assessment assumes vertical homogeneity in soil characteristics within the vadose zone. In reality, there is variation

in soil characteristics with depth along the vadose zone. Due to the nature of vertical variation in soil along the vadose zone, this constraint may result in either an overestimate or underestimate of the calculated flux. The models also do not account for horizontal transport of chemicals within the vadose zone. If impacted soil is highly localized (i.e., high concentrations are surrounded by low concentrations), horizontal transport tends to dilute the localized impacted soil and decrease the flux of chemicals to the atmosphere. For this case, the true flux and estimated risks could be lower than presented in this assessment.

The uncertainties in the calculated indoor air concentrations as a consequence of the modeled fluxes are mostly associated with the assumed parameters and structure of a residential home. First and most importantly, the attenuation through the slab of a house is a difficult parameter to characterize. In this assessment, two methods of assessing this attenuation were carried out. Using the VLEACH model, a reduction of 90 percent (i.e., 10 percent penetrates the slab – a slab attenuation factor of 0.1) was assumed through the slab as a conservative estimate for residential buildings. This 10 percent value is conservative and would likely to be lower for newer homes where the slab is assumed to be in good condition. Changes in the slab attenuation factor have a direct linear relationship with the resulting transfer factors and an indirect linear relationship with estimated risks. For example, a new slab with a lower slab attenuation factor would allow less chemical flux through the floor (i.e., a higher transfer factor) and would lead to lower indoor air concentrations than predicted in this risk assessment. In contrast, the Johnson and Ettinger model (EPA, 2000a) has an approximate model of migration through a slab built into it. It contains various uncertain parameters, such as the pressure differential between the soil and the building and a floor-wall seam crack width. Lacking estimates of these values, default values were used.

Actual attenuation through a building slab is difficult to measure or model. Factors that influence it include the degree of cracking of the slab, the permeability of the soil underlying the slab, whether there is more permeable surface nearby (i.e., grass), and building construction. Buildings that are constructed with air space between the soil and the living space (i.e., those with open basements or crawl spaces) would have greater attenuation of chemical migration into the home because the air space serves to passively vent vapors from the soil.

By having two models of migration through the building slab and arriving at similarly low estimates of risk, it appears that uncertainties in the vapor migration model, including both how they model migration through soil and into a building, are not particularly significant. There, however, may be uncertainty in the common parameters used by the two models, including mixing height and air exchange rate.

Uncertainty that may be associated with mixing height can occur if ventilation between the first floor and attic or second floor is good. The effect of a change in this factor is a simple linear extrapolation on the corresponding transfer factor. As an example, if homes have good ventilation between first and second floors, a mixing height of 16 feet, rather than 8 feet, may be justified, which would reduce transfer factors by a factor of two and decrease risk by a factor of two.

Sensitivity in air exchange rate is also easily calculated, in that a doubled exchange rate reduces the transfer factors by two resulting in increased air concentrations by a factor of two. The air exchange rate can be different depending on whether ventilation in the home is aided by windows or doors being open or closed. The value used in this assessment is 0.45 hr^{-1} based on studies by Koontz and Rector (1995) and Parker et al. (1990). However, if the air exchange rates in future homes were greater than 0.45 hr^{-1}, the risk would be lower than presented in this report. Similarly, if future homes have lower air exchange rates than 0.45 hr^{-1}, the risks would be higher than those presented in this report. Risks are directly proportional to air exchange rates such that an increase or decrease in air exchange by a factor of two would result in a two-fold decrease or increase in the risk estimates, respectively.

Another uncertainty considered is the fate of vapor flux that does not enter buildings. This flux is attenuated, in part as flux into surrounding outdoor air. In modeling the flux into indoor air, it is implicitly assumed in both the VLEACH and Johnson and Ettinger approaches that the outdoor air is clean. This assumption is based in experience where outdoor box models, using even a conservative windspeed of 1 meter per second as used at this site, dilute the flux from the subsurface approximately 300 times more than indoor box models. Hence, by ignoring potential vapor flux impact into outdoor air and subsequent mixing with indoor air, the error induced is on the order of 1 percent or less.

Both techniques of vapor modeling also assume that there is no subsurface pressure gradient driving vapors upward. There are some indications of methane at the site, which can suggest subsurface pressure gradients. However, the levels of methane are low and would not likely be indicators of subsurface pressure gradients that would induce convective vapor flow on top of the diffusive vapor migration evaluated. If convection of methane were occurring, it would increase the migration rate of other vapors. Limited methane gas analyses will be performed on soil gas samples collected as part of the regular groundwater monitoring at the site to verify this.

An additional uncertainty in the indoor air risk evaluation stems from the reliance on soil gas data that are not correlated well with underlying groundwater concentrations. This lack of

correlation suggests that the source of the soil gas is not clear. By assuming a long-term steady groundwater volatilization source for the VLEACH modeling and by using the maximum observed soil gas values in generating risk calculations, this uncertainty is being handled through a very conservative approach.

The U.S. Coast Guard has recently collected indoor and outdoor air samples at locations within the boundaries of OU-5. Approximately 17 air samples, plus one duplicate and two field blanks, were collected in passivated canisters in selected housing complexes on Mayport Circle, Annapolis Circle, Singleton Avenue, and Mosley Avenue. Nine of these samples were interior air samples, four were exterior samples, and four were collected in crawl spaces beneath the homes. Another 17 air samples, plus two duplicates, were collected in selected housing complexes on Kollmann Circle. The air samples were analyzed for benzene, and other VOCs, using EPA Method TO14.

Analytical data were not received in time to allow for their quantitative use in this risk assessment. A cursory examination of the unvalidated benzene data presented in the laboratory reports from samples collected at four locations on Mayport Circle and Singleton Avenue indicates that interior benzene air concentrations and benzene concentrations in exterior air samples are roughly equivalent. Benzene concentrations in crawl spaces in these same four locations were noticeably lower than in either interior or exterior air. This preliminary evaluation suggests that ambient air may be a primary source of the benzene measured in indoor air.

5.9.8.3 Toxicity Assessment

There are a number of uncertainties in conducting a toxicity assessment. The primary areas of uncertainty include the assumption that adverse effects observed in animal experiments would also be observed in humans (animal-to-human extrapolation), and that the toxic effects observed after exposure by one route would occur following exposure by a different route (route-to-route extrapolation [e.g., ingestion vs. inhalation]). Uncertainties in the toxicological assessments for carcinogens and noncarcinogens are discussed below.

Quantitative estimates of CSFs and noncancer RfDs have not yet been developed for the dermal route. As stated in EPA guidance (1989), oral RfDs and CSFs should therefore be used to assess toxicity from dermal exposure to chemicals. However, performing this route-to-route extrapolation introduces some additional uncertainty to the risk and hazard index estimates. Specifically, dermal exposure can result in different patterns of distribution, metabolism, and

elimination than would occur from the oral route. Such differences are not accounted for when applying the oral toxicity values to dermal exposure.

Carcinogens. First, the use of animal data presents an uncertainty in predicting carcinogenicity in humans. While many substances are carcinogenic in one or more animal species, only a small number of substances are known to be human carcinogens, raising the possibility that not all animal carcinogens are human carcinogens and that not all human carcinogens are animal carcinogens. To prevent the underestimation of carcinogenic risk, regulatory agencies generally assume that humans are at least as sensitive to carcinogens as the most sensitive animal species.

Because most CSFs are an upper 95th percentile estimate of potency, and because upper 95th percentiles of probability distributions are not strictly additive, the total estimated cancer risk for an exposure pathway might become artificially more conservative as risks from a number of different carcinogens are summed. Similarly, substances with different weights of evidence for human carcinogenicity are summed equally, giving as much weight to group B or C carcinogens as to group A carcinogens. For example, BaP is considered a class B2 carcinogen, indicating that it may be a human carcinogen, but there is inadequate evidence from human epidemiological studies. Since BaP is used to normalize toxicity for all other carcinogenic PAHs, the risks associated with these chemicals may be overestimated. Only 5 of the 25 chemicals included in this study for which cancer risks were calculated are considered known Group A carcinogens.

The development of CSFs for carcinogens is predicated on the assumption generally made by regulatory agencies that no threshold exists for carcinogens (i.e., that there is some risk of cancer at all exposure levels above zero). The no-threshold hypothesis for carcinogens; however, has not been proven and may not be valid for substances that have been shown to be carcinogenic via other mechanisms (e.g., mechanisms that do not appear to act directly on genetic material).

Noncarcinogens. In order to adjust for uncertainties that arise from the use of animal data, regulatory agencies often base the RfD and RfC for noncarcinogenic effects on the most sensitive animal species (i.e., the species that experiences adverse effects at the lowest dose). The doses are then adjusted via the use of safety or uncertainty factors. The adjustment compensates for the lack of knowledge regarding interspecies extrapolation and guards against the possibility humans are more sensitive than the most sensitive experimental animal species tested. The use of uncertainty factors is considered to be health protective. In addition, when route-specific toxicity data were lacking, one route was extrapolated to another (i.e., oral to

inhalation). Due to the absence of contrary data, equal absorption rates are assumed for both routes.

Methane. As discussed in Section 5.5.2, methane was detected in both direct-push and monitoring well groundwater samples, with a maximum detected concentration of 10 mg/L. Soil gas samples were not analyzed for methane. Methane is a simple asphyxiant and potential fire and explosion hazard when exposed to heat or flames. In the absence of soil-gas data for methane, a concentration of methane in the gaseous phase was estimated using Henry's Law. This calculation yields a maximum estimated concentration of methane gas of approximately 500 parts per million. This value is well below the lower explosive limit given for methane of 50,000 parts per million. However, due to the uncertainties in this calculation, methane gas analyses will be performed on soil gas samples collected as part of the regular groundwater monitoring at the site.

5.9.8.4 Risk Characterization

Uncertainties in the calculation of risks include both uncertainties due to the different methodologies used and due to the conservative nature of the assumptions used in the calculation of risks.

U.S. Environmental Protection Agency versus California Environmental Protection Agency Methodology. This risk assessment was "dual tracked." This means that risks were calculated separately using EPA and CalEPA risk assessment methodology. Differences in these methodologies include limited exposure assumptions, hierarchy of toxicity values, and preferred model for estimating the migration of volatile chemicals through soil and into indoor air. As shown in Section 5.9.3, although there were some differences in PAH risk estimates for the current and future residential scenarios, the overall conclusions were similar. With one exception (decision area 7), total estimated cancer risks for current and future residents fell below the upper bound of the target risk range of 10^{-6} to 10^{-4}, assuming no exposure to soils below 4 feet. However, risk associated with potential future residential exposure to soils below 4 feet in decision areas 2, 3, 6, and 7 exceeded 10^{-4}. For construction workers, the estimated cancer risks for Parcel 181 and the Northern Parcel fall into the target risk range of 10^{-6} to 10^{-4}. For the Southern Parcel, the estimated risk is at the lowest end of the target range. For both methods, the estimated noncancer HIs for PAHs at all depths and decision areas were less than 1 for residents and construction workers.

For residential exposure to metals in soil, the results for both methods were also similar. The estimated cancer risk for all depth intervals ranged from 7×10^{-6} to 8×10^{-6} for current child

residents and 8 x 10^{-7} to 1 x 10^{-6} for current adult residents. For both methods, the estimated cancer risk for all depth intervals was 1 x 10^{-5} for potential future residents. The major chemical contributor to the estimated cancer risk is arsenic. For construction workers, the estimated cancer risks ranged from 7 x 10^{-7} (EPA methodology) to 4 x 10^{-6} (Cal EPA methodology). This difference is mainly due to the differences in the inhalation CSFs for the two agencies. With a few very slight exceptions, HIs for metals across all depths were identical for the EPA and CalEPA methodologies.

Soil gas data collected at the site were used to evaluate residential indoor air risk due to VOCs migrating through subsurface soil and into a residence. The screening evaluation was conducted using the maximum detected concentration for each chemical detected regardless of location and depth. Flux into a residential building was calculated using two different commercially-available transport models, VLEACH (EPA methodology) and Johnson and Ettinger (CalEPA methodology). Although estimated indoor air concentrations were different between the two transport models, calculations performed using both transport models estimated residential cancer risks were well below 10^{-6} (maximum residential cancer risk of 4 x 10^{-8}) and HIs were well below one (maximum residential HI of 0.06).

Both groundwater and soil gas data was used to evaluate potential construction worker exposure to volatile chemicals that migrate as vapors into a trench during construction activities. Screening was conducted using VLEACH for both the EPA and CalEPA methodologies. For both methodologies, the estimated cancer risks for the maximum soil gas, shallow groundwater (direct-push), and shallow groundwater (monitoring wells) were well below 10^{-6} (maximum construction trench risk of 7 x 10^{-10}) and the HIs were well below one (maximum construction trench HI of 0.0008).

Risk Calculations. As discussed in Section 5.8, most CSFs are an upper 95th percentile estimate of potency. Because upper 95th percentiles of probability distributions are not strictly additive, the total estimated cancer risk may become artificially more conservative as risks from a number of different carcinogens are summed. Similarly, we summed the chronic hazard quotients of chemicals not expected to induce the same type of effects or that do not act by the same mechanism. This tends to overestimate the total estimated chronic HI.

The EPA (1989) notes that the conservative assumptions used in a risk assessment are intended to assure that the estimated risks do not underestimate the actual risks posed by a site and that the estimated risks do not necessarily represent actual risks experienced by populations at or near a

site. By using standardized conservative assumptions in a risk assessment, EPA further states that:

> *"These values [risk estimates] are upperbound estimates of excess cancer risk potentially arising from lifetime exposure to the chemical in question. A number of assumptions have been made in the derivation of these values, many of which are likely to overestimate exposure and toxicity. The actual incidence of cancer is likely to be lower than these estimates and may be zero."*

The estimated risks in this risk assessment are based primarily on a series of conservative assumptions related to predicted environmental concentrations, exposure, and chemical toxicity. The use of conservative assumptions tends to produce upper-bound estimates of risk. Although it is difficult to quantify the uncertainties associated with all the assumptions made in this risk assessment, the use of conservative assumptions is likely to result in substantial overestimates of exposure, and hence, risk.

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6.0 Summary and Conclusions

Summaries of the results of data analysis and risk assessment activities, described in detail in Sections 4.0 and 5.0 of this Remedial Investigation (RI) Report, are presented in Sections 6.1 and 6.2. Conclusions relative to the investigation and proposed remedial action objectives for Operable Unit (OU) 5 are provided in Section 6.3.

6.1 Summary of the Nature and Extent of Chemical Contamination

The soil data analysis and risk assessment summarized here is based on sampling conducted in Parcel 181. However, the scope of the groundwater and soil gas investigation extended beyond Parcel 181 to investigate the boundaries and possible origins of chemical constituents in these media.

Soil benzo(a)pyrene (BaP)-equivalent concentrations were calculated for each soil sample by normalizing the concentration of each carcinogenic polynuclear aromatic hydrocarbon (PAH) to the carcinogenicity of BaP using U.S. Environmental Protection Agency (EPA) toxicity equivalency factors (TEF). Soil BaP-equivalent concentrations were also calculated using California Environmental Protection Agency (CalEPA) TEFs. Differences between EPA and CalEPA BaP-equivalent concentrations were relatively slight. Therefore, although only EPA BaP-equivalent concentrations were used for evaluating the nature and extent of contamination, the findings would generally be the same if CalEPA values were used.

Benzo(a)pyrene-equivalent soil concentrations show a general trend from higher to lower from north to south and from west to east across Parcel 181. Benzo(a)pyrene-equivalent soil concentrations also generally increase with depth in the northern and western portions of Parcel 181. A semiquantitative analysis of BaP-equivalent soil concentration data from 0 to 4 feet below ground surface (bgs) supported stratification of Parcel 181 into seven decision areas. These seven areas group the individual housing areas in a way that minimizes the variance in soil BaP-equivalent soil concentrations within 4 feet of the ground surface. Although the large-scale variability in BaP-equivalent soil concentrations supported the identification of seven distinct areas of BaP-equivalent soil concentrations, there was considerable variability observed both among adjacent sampling locations and within homogenized splits of a single sample. Analysis of BaP-equivalent soil concentration data from the 4 foot bgs to 8 foot bgs depth interval supported differentiation of only two areas over the deeper interval; the northern and southeastern portions of Parcel 181.

An evaluation of metal concentrations in soil at Parcel 181 revealed only slight spatial patterns with area or depth. Comparison of Parcel 181 soil metal concentrations with background levels is complicated by the fact that an applicable background data set for rigorous comparisons does not exist (Section 2.5 of Appendix B). The box plot comparisons of OU-5 concentrations of arsenic, cadmium, chromium, copper, lead, and mercury with background concentrations (presented in Appendix B) suggest that concentrations of arsenic, chromium, copper, lead and mercury are elevated relative to the "pink" data set. However, none of the six metals evaluated are present at concentrations that are consistently higher then the other Alameda background data sets, or higher than sediment ambient data, or are present in a pattern that would denote a surface spill.

While there were four target sampling interval depths for groundwater, samples could not be collected from some of the intervals due to lack of water or very low productivity because of an abundance of fine-grained material in the target interval. Therefore, much of the groundwater data were obtained from two intervals (the intermediate sampling interval [12 to 16 feet bgs] and the sampling interval above the marsh crust [16 to 20 feet bgs]).

Soil gas samples were to target the 2 foot bgs and 5 to 7 foot bgs depth intervals. However, approximately one-third of the sample collection attempts from the 5 to 7 foot depth interval were successful while all but one from the 2 foot depth interval were successful. Wet soil conditions limited the sampling success.

Data analysis was focused on benzene and naphthalene due to their relatively high detection frequency, potential for migration, and toxicity. The groundwater plume of these volatile organic compounds (VOC) was not bounded to the west and south and their source is likewise uncertain. However, the benzene and naphthalene plumes are positioned at roughly the same locations suggesting an identical source(s). Additionally, concentrations of other petroleum-related compounds including toluene, ethylbenzene, and xylene were present with benzene and naphthalene. Concentrations of 1,2-dichloroethane and MTBE, which are indicative of more recent releases than that associated with historical industries, were also present. The 1,2-dichloroethane plume roughly coincides with the benzene and naphthalene plumes. Detected MTBE concentrations did not show a discernable pattern.

Potential sources based on the spatial distribution of VOC concentrations in groundwater include the Fleet and Industrial Supply Center Oakland (FISCO) Alameda Annex Scrapyard Installation Restoration (IR) Site 02 and the area in the southwest corner of Parcel 181 where soil staining was observed in historical photographs. The marsh crust layer of hydrocarbon contamination

that exists at approximately 20 feet bgs may also contribute to the presence of petroleum-related compounds in groundwater. Benzene and naphthalene concentrations appear to increase with depth between the water table and the marsh crust, although a more widespread distribution of benzene and naphthalene in groundwater would be expected if the marsh crust were the primary source of these chemicals. The presence of MTBE and 1,2-dichloroethane in groundwater near the FISCO Annex indicates a source other than that associated with historical oil refining.

There seems to be little volatilization of benzene or other VOCs to soil. The VOCs were reportedly present at higher concentrations in groundwater samples collected from 16 to 20 feet bgs. Contaminant concentrations in groundwater collected from more shallow depths were less than those reported for samples from the 16 to 20 foot depth. Since the higher groundwater concentrations were present at greater depths, high soil gas concentrations would not be expected in the 2 foot bgs and 5 to 7 foot bgs soil gas sample intervals.

6.2 Summary and Conclusions of the Human Health Risk Assessment

The human health risk assessment estimated the cancer risks and noncancer hazard indices (HI) associated with potential exposure to chemicals identified in soil, shallow groundwater, and soil gas at the North Village Housing Area (Parcel 181) under current and possible future site conditions. Based on current Navy policy, the risk assessment was "dual tracked." This means that risks were calculated separately using both EPA and CalEPA risk assessment methodologies. Areas where the federal and state methodologies differ are noted throughout the risk assessment, but consist mainly of exposure assumptions, toxicity values, and fate and transport model selection.

The current scenario includes residents (adults and children) of the existing housing units. In addition, the property may be redeveloped as residential housing in the future under a different housing configuration. For this reason, future residents (adults and children) and construction workers are also identified as potential receptors.

The current and future residential exposure scenarios differ owing to a shorter exposure duration for current Coast Guard residents (6 years versus 30 years) and the fact that exposure to soils below a depth of 4 feet is considered unlikely for current residents. However, both the current and future scenarios were evaluated using exposure parameters consistent with reasonable maximum exposure (RME) conditions. Although residential receptors may engage in recreational activities at the site, a separate evaluation of risks for a recreational user was not performed because the residential land-use scenario provides the greatest potential for exposure to site-related chemicals.

Current and future residents could be exposed directly to chemicals remaining in near surface soil on the site. Potential routes of exposure to near surface soils include incidental ingestion, dermal contact, and inhalation of windblown particulates. For current residents, exposure to chemicals in the 0 to 0.5 foot bgs, 0 to 2 foot bgs, and 0 to 4 foot bgs depth intervals were evaluated. The 0 to 0.5 foot bgs interval is the most likely for direct contact by current residents. The 0 to 2 foot bgs and 0 to 4 foot bgs were evaluated to assess the consequences of potential contact with deeper soils during digging activities.

For future residents, exposure to chemicals in the 0 to 0.5 foot bgs, 0 to 2 foot bgs, 0 to 4 foot bgs, and 0 to 8 foot bgs depth intervals was evaluated. If the current buildings remain in the future, the 0 to 0.5 foot bgs interval would be the most likely for exposure by direct contact. The 0 to 2 foot bgs interval and 0 to 4 foot bgs interval were evaluated assuming that soils to these depths may be mixed during redevelopment activities. Although the 0 to 8 foot bgs interval has been included in this assessment, it is considered unlikely that redevelopment activities would mix soils to this depth over significant areas of the site. Sampling density is higher in the surface soils because these soils are expected to be the primary exposure medium; therefore, fewer soil samples were collected below 4 feet bgs and only PAH data in the 0 to 4 foot depth interval were used to define decision areas for the residential scenario (Neptune and Company, 2001). Consequently, there is less confidence in residential risk estimates for the 0 to 8 foot bgs depth interval than in shallower depth intervals.

Residents may be exposed to VOCs in subsurface soil and groundwater that migrate as vapors through soil and into outdoor air and indoor air either via cracks in a cement slab or via a crawlspace. Therefore, potential exposures resulting from the inhalation of vapors that have migrated through the soil column were quantified in this assessment for residents (indoor air) based on the soil gas sampling results. Only the inhalation of volatile chemicals in indoor air was modeled for residential populations since outdoor concentrations will be lower than indoor air concentrations due to higher mixing in the ambient environment.

A construction worker scenario was evaluated in addition to the residential scenarios because such workers are more likely to be exposed to chemicals in deeper soils as well as VOCs in groundwater. For example, construction workers could be exposed to VOCs in shallow groundwater that migrates as vapors into a trench during construction activities.

As discussed in Section 6.1, BaP-equivalent soil concentrations were used to identify seven decision areas for the residential risk assessment. With one exception (decision area 7), total estimated cancer risks for current and future residents in the decision areas fell below the upper

bound of the target risk range of 10^{-6} to 10^{-4}, assuming no exposure to soils below 4 feet. However, risk associated with potential future residential exposure to soils below 4 feet in decision areas 2, 3, 6, and 7 exceeded 10^{-4}

For residential exposure to metals in soil, the estimated residential cancer risk for all depth intervals ranged from 7×10^{-6} to 8×10^{-6} for current residents and 1×10^{-5} for potential future residents. The major chemical contributor to the estimated cancer risk is arsenic. Because evaluation of arsenic showed that concentrations present in site soils are consistent with the local ambient levels, these risk values may be subtracted from the total risk estimates described in the previous paragraph to estimate site-related incremental cancer risks. Chemical HIs were calculated as the sum of chemical-specific hazard quotients for individual PAHs and metals in soil. Calculated chemical HIs ranged from 0.7 to 1 for both current and future residential scenarios, with the slightly higher values associated with deeper soil depth intervals. Ambient concentrations of metals were responsible for the majority of the chemical hazard in both current and future residential risk scenarios. The only occasion of an HI exceeding one occurred in the 0 to 8 foot depth interval in decision area 2, where a value of two was calculated. This value of two is the sum of metals-related hazard (1) and PAH-related hazard (0.7). With a few very slight exceptions, HIs for metals and PAHs across all depths and decision areas were identical for the EPA and CalEPA methodologies.

Soil gas data collected at the site were used to evaluate residential indoor air risk due to VOCs migrating through subsurface soil and into a residence. Because the soil gas samples are distributed both onsite and off site, a screening evaluation was conducted to determine the significance of this potential exposure pathway. The screening evaluation was conducted using the maximum detected concentration for each chemical detected regardless of location and depth. Volatile organic compound flux into a residential building was calculated using two different commercially-available transport models. Although estimated indoor air concentrations were different between the two transport models, calculations performed using both transport models estimated residential cancer risks well below 10^{-6} and HIs below one. Therefore, no refinement of the VOC-related risk calculations using exposure concentrations other than the maximum detected concentration was performed.

For construction workers, cancer risk and noncancer HIs related to PAHs in soil were evaluated across all of Parcel 181 and by the northern and southern parcels of Parcel 181. The estimated PAH-related cancer risks for Parcel 181, northern area, and southern area were 3×10^{-6}, 6×10^{-6}, and 8×10^{-7}, respectively (EPA methodology). For the CalEPA methodology, estimated PAH-related cancer risks for Parcel 181, northern area, and southern area were 9×10^{-6}, 2×10^{-5},

and 2 x 10^{-6}, respectively. A hazard index of approximately 0.5 was calculated for exposure to metals in soils for all three areas by both methodologies. Both cancer risk and hazard associated with potential exposure to VOCs during trenching activities were determined to be negligible using a screening-level approach analogous to that employed for the residential scenario.

The risk assessment assumed that no further remediation has been conducted at the site since the RI field activities conducted in 2001. However, as discussed in Section 2.6 of this RI Report, a risk management decision was made by the Navy to conduct a time-critical removal action (TCRA) at Parcel 181 (North Village Housing Area). The TCRA activities removed soils to a depth of 2 feet bgs in decision areas 4, 5, and 7, and backfilled with clean fill, topsoil, and sod. This effectively eliminates the direct contact pathway in these areas. As the largest overall contributor to the risks estimates is direct contact with soil, this interim action will effectively eliminate incremental cancer risk and chemical hazard associated with exposure PAHs in near surface soil in these decision areas.

6.3 Conclusions

The results of the human health risk assessment indicate that current and potential future reasonable-maximum residential cancer risks lie mostly within the 10^{-6} to 10^{-4} risk management range (excepting decision area 7) when assessing exposure to soil depths of 4 feet bgs. A risk management decision has already been made to remove soils to a depth of 2 feet bgs in decision areas 4, 5, and 7 where shallow-soil BaP-equivalent concentrations appeared highest during an initial data review. If chronic exposure occurs to soils that are mixed to depths of 8 feet bgs, estimated cancer risks greater than 10^{-4} are calculated for decision areas 2, 3, 6, and 7.

6.4 Proposed Remedial Action Objectives

The proposed remedial action objectives presented below will be further refined in the feasibility study based on the site-specific constituents of concern that constitute the basis for the development of remedial alternatives in the feasibility study. The following sections discuss the proposed remedial action objectives for both soil and groundwater.

6.4.1 Proposed Remedial Action Objectives for Soil

The RI activities and findings summarized and evaluated in this RI Report indicate that mitigation of soil contamination may be required to protect human health. Although arsenic was found to be present at concentrations that might represent a threat to human health, concentrations of metals in soils were also shown to be consistent with those at Alameda Point and throughout the San Francisco Bay Area. No mitigation of arsenic is required because of the similarity to regional background concentrations. Residential risk estimates related to PAH

concentrations in the upper 4 feet of soil generally lie within the target risk range of 10^{-6} to 10^{-4} while PAH concentrations and associated risk below 4 feet are generally higher. Polynuclear aromatic hydrocarbon-contaminated soils may require remediation. To mitigate the soil contamination in compliance with the National Oil and Hazardous Substances Pollution Contingency Plan procedures and the Comprehensive Environmental, Response, Compensation, and Liability Act requirements the following proposed remedial action objectives have been established for soil in OU-5:

1. Prevent human exposure to soil containing PAHs at concentrations that represent an incremental lifetime cancer risk exceeding the approximate mid-point of the NCP risk range.
2. Reduce the mass and concentration of PAHs in the soil where it is economically feasible to do so.
3. Comply with Applicable or Relevant and Appropriate Requirements (ARAR) associated with the selected remedial action (s).

6.4.2 Proposed Remedial Action Objectives for Groundwater

The risk assessment presented in this RI Report indicated that the organic chemicals present in groundwater at OU-5 do not pose a threat to human health via the dermal contractor inhalation exposure pathways. Risks associated with the ingestion pathway was not considered because of the approved Determination of the Beneficial Use of Groundwater Technical Memorandum (TtEMI, 2000b).

Future demand for a limited water resource may result in a reevaluation of the utility of groundwater at OU-5. To mitigate the groundwater contamination in compliance with the National Contingency Plan and Comprehensive Environmental Response, Compensation, and Liability Act, and to aid in protecting human health in the event of future changes to the groundwater designation, the following proposed remedial action objectives have been established for groundwater in OU-5:

1. Prevent human exposure to groundwater containing volatile and semivolatile organic compounds at concentration greater than chemical-specific ARARs.
2. Prevent the degradation of nearby groundwater resources.
3. Comply with all other ARARs associated with the selected remedial action(s).

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